THE UNIAXIAL MECHANICAL RESPONSE OF MULTI-RIDGE ICE

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SUMMARY REPORT

BY

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ABSTRACT

The mechanical properties from the uniaxial compression tests conducted in Phase I of the Mechanical Properties of Sea Ice program are summarized. The tests were conducted at temperatures of -5°C amd -20°C and at strain rates of 10^{-5} and 10^{-3}/sec. The effects of temperature and strain rate on each mechanical property are investigated. Each stress-strain curve is presented and an energy based parameter is derived to characterize the mechanical response of each curve. The effects of temperature and strain-rate on this parameter are also investigated. The physical properties of each test sample are listed, and their effect on the mechanical properties is briefly discussed.

KEY WORDS: ice mechanics, ridge, ice formed feature, mechanical property, statistical analysis, compressive strength, strain, linear, regression analysis, prediction, testing, stress, load (force), energy, temperature

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INTRODUCTION

The Mechanical Properties of Sea Ice (MPSI) is a project, consisting of several phases, to determine the mechanical properties of multi-year sea ice. The project was developed and administered by Shell Development Company. Participants sponsoring Phase I of the project (MPSI-1) included Amoco Production Company, Arco Oil and Gas Company, Chevron Oil Field Research Company, Exxon Production Research Company, Gulf Research and Development Company, Minerals Management Service of the Department of Interior, Mitsui Engineering and Shipbuilding Company, Sohio Petroleum Company, and Texaco Incorporated. The field program to collect ice samples and the experimental program for ice testing were conducted by the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) at Hanover, New Hampshire.

The experimental program in MPSI-1 was designed to accomplish three goals:

1. Measure the mechanical (i.e., 1-D compressive) properties of multi-year ridge ice,
2. Determine whether there is any significant variation in the mechanical properties within and between ridges, and
3. Develop the test techniques to be used in subsequent phases of the program.

The results presented here summarize the approximately 200 uniaxial compression tests conducted in MPSI-1. These tests have already been documented by Cox et al.[1] in a CRREL report and several excerpts have been presented as technical papers by individual CRREL authors.[2-4] The CRREL report[1] describes the field program and experimental program in detail and presents the mechanical and physical properties of each test sample. The purpose of this report is to present an analysis of the digitized test data which complements and expands upon CRREL's analyses by utilizing the entire stress-strain history of each test.

The ice samples tested were extracted with a 4 1/4 in. diameter core barrel in the spring of 1981 from ten multi-year pressure ridges located in the Beaufort Sea, northwest of Reindeer Island. The ice samples were transported to the CRREL laboratories and prepared for testing. Sample preparation included cutting each sample to length, machining the samples to test geometry, and fitting the ends with synthane endcaps. The samples were then tested under uniaxial test conditions. Mellor et al.[5] describe the details of sample preparation and testing techniques.

The mechanical properties were measured by Cox et al.[1] at two temperatures (i.e., -5°C, -20°C) and two strain rates (i.e., 10^{-5}/sec, 10^{-3}/sec). These temperatures and strain rates were chosen to bracket the temperature and strain rate regimes of most interest to the engineer. To characterize the ice, physical properties (e.g., brine volume, porosity, etc.) of each sample were measured. To better define the physical properties of each ice sample, Cox and Weeks[6] developed a method of calculating the air volume of the sample. This method permits the total porosity to be calculated by knowing both the air volume and brine volume. A statistical summary of the mechanical properties shows large scatter which is attributed to the wide variation of ice types found in multi-year ridges. Richter and Cox[3] developed a classification scheme for multi-year ridge ice which offers a means of reducing the scatter by grouping tests according to ice structure. This classification scheme was applied to approximately 35 test samples in Phase I, and a forthcoming report by Richter-Menge and Cox will contain additional crystallographic analyses of MPSI-1 test samples.

Weeks[4] investigates the statistical variation of strength within and between ridges. Based on these statistics, he concludes that there is no significant variation between cores at the same site (i.e., within the same ridge) nor is there any significant differences between ridges. However, Weeks qualifies his conclusions by pointing out that the ridges used in this study represent old, well-healed ridges whose strength characteristics are probably quite different than younger, less consolidated ridges.

Subsequent phases of the program will emphasize other types of tests to give a complete picture of the mechanical response of multi-year ridge ice. To this end, test techniques were developed for uniaxial tension, constant load compression, and conventional triaxial tests. The conventional triaxial tests are conducted by applying the confining pressure in proportion to the axial stress. These test techniques are discussed by Mellor et al.[5]

The goal here is to describe the mechanical (i.e., uniaxial compression) response as a whole by looking at the stress-strain curves. We begin by listing the mechanical properties and describing the effects of temperature and strain rate on those properties. The mechanical properties are then integrated in such a way as to yield a quantity which characterizes a particular stress-strain curve. The variation in the mechanical response at each test condition will be illustrated, and the ability to characterize each stress-strain curve will permit a discussion of changes in mechanical response with changes in temperature and strain rate.

The stress-strain curves presented here were produced by digitizing the analog records of each test and fitting splines to the digitized data. To make the splines suitable for future constitutive modeling, certain assumptions were made about the initial conditions of the force-time record which yielded different values for the mechanical properties than those reported by Cox et al.[1] These differences are small except in one case which will be noted later. The assumptions made and procedures followed in processing the data are described in Appendix A. The spline for each force-time history is printed in Appendix B and each stress-strain curve is presented according to test condition in Appendix C.

For completeness, the physical properties measured by Cox et al.[1] will be listed here. Although the large variations in mechanical properties and mechanical response of multi-year ridge ice are related to the physical properties of each test sample, discussion will be limited because of the limited amount of crystallographic data presently available. Attempts, however, will be made to establish bounds and identify trends for the dependence between mechanical and physical properties. The pending crystallographic analysis by Richter-Menge and Cox will permit a more detailed look into the effects of physical properties.

MECHANICAL PROPERTIES AND STATISTICAL SUMMARY

The uniaxial compression test samples in MPSI-1 were taken from ten multi-year pressure ridges in the Beaufort Sea. At each ridge, two sites were selected several meters apart. At a particular site, the samples were extracted from two cores several centimeters apart. Each sample was labeled with a Ridge ID, whose nomenclature identified the ridge, core (and site), and depth of the sample. The designations R1 through R10 in the Ridge ID identify the ridge and the letters A-D identify the core. The letters A, B designate the cores at one site while the letters C, D designate the cores at the second site. The depths in centimeters from the top of the ridge to the top and bottom of the ice samples are denoted in the Ridge ID by the two numbers separated by a slash. Thus a sample designated R1A-062/089 would indicate a sample taken from Ridge 1, site 1, core A, and a depth of 62 centimeters to the top and 89 centimeters to the bottom of the sample.

The uniaxial compression tests were conducted at two temperatures (i.e., T = -5°C, T = -20°C) and two strain rates (i.e., $\dot{\varepsilon} = 10^{-5}$/sec, $\dot{\varepsilon} = 10^{-3}$/sec). The four possible combinations of temperatures and strain rates give four independent test conditions. For convenience in later discussions, the test conditions are assigned labels which are listed in Table 1. In the following data summaries, all tests are grouped according to test conditions. Each test within a test condition group is identified by the Ridge ID of the test sample.

Following the procedures discussed in Appendix A, stress-strain curves were generated for each test from which the mechanical properties were calculated. The particular mechanical properties considered in the analysis of the stress-strain curves are described in Table 2. This list includes the mechanical properties commonly used by engineers to describe the mechanical response of other materials as well as additional properties not usually calculated. The additional properties include the energy dissipated at peak strength, the total energy dissipated, "flow" energy, and "crushing" energy. The flow and crushing energy terms are obtained from a decomposition of the total energy and will be defined in the next section. For completeness, the failure modes defined by Dorris[7] are included but will not be discussed here.

In Table 2, the most important quantities used to describe the mechanical response of multi-year ridge ice are σ_M, ε_M, E_T, σ_R, and I_T. The quantity, I_T, is the integral of the stress-strain curve and measures the

Table 1

IDENTIFYING LABELS FOR EACH TEST CONDITION

$\dot{\epsilon}$ \ T	-5°C	-20°C
10^{-5}/sec	C55	C520
10^{-3}/sec	C35	C320

Table 2

DESCRIPTION OF MECHANICAL PROPERTIES

Mechanical Property	Description	Units
σ_M	Maximum Stress	psi
ε_M	Strain at Maximum Stress	%
σ_R	Residual Stress (Stress at 4.5% Strain)	psi
ε_E	Strain at End of Test	%
E_T	Initial Tangent Modulus	psi × 10^6
E_S	Secant Modulus $E_S = \frac{\sigma_M}{\varepsilon_M}$	psi × 10^6
σ_R/σ_M	Stress Ratio	---
FM	Failure Mode	---
I_P	Energy to Maximum Stress $I_P = \int_0^{\varepsilon_M} \sigma(\varepsilon)d\varepsilon$	(in-lbf)/in^3
I_T	Energy to 4.5% Strain $I_T = \int_0^{.045} \sigma(\varepsilon)d\varepsilon$	(in-lbf)/in^3
I_F	Flow Energy $I_F = 1/2\left(.09 - \frac{\sigma_R}{E_T}\right)\sigma_R$	(in-lbf)/in^3
I_C	Crushing Energy ($I_C = I_T - I_F$)	(in-lbf)/in^3
I_C/I_F	Energy Ratio	---

material's ability to store or dissipate energy. The spatial distribution of I_T in the stress-strain plane characterizes the material's response as either brittle or ductile. For multi-year ridge ice, the quantities σ_M, ε_M, E_T and σ_R can approximate the spatial distribution of I_T by defining the initial condition, peak value, and final value of the material response. In the following, these five quantities will be referred to collectively as primary properties.

In contrast to σ_M, ε_M, and E_T, the primary properties σ_R and I_T are arbitrary since their value depends on the choice of strain at which they were calculated. Each test was programmed to end at 5% strain, but the procedures followed in processing the data resulted in tests with varying lengths slightly less than 5% strain. In order to make meaningful comparisons between the properties associated with the end of the test, 4.5% strain was arbitrarily chosen to be the strain at which σ_R and I_T are calculated.

The mechanial properties are tabulated for each test according to the four test conditions in Tables 3-6. Any test in these tables having missing values indicates a test which did not reach 4.5% strain due to premature failure of the test sample. All available mechanical properties are used in the following statistical summary of properties, but only those tests which reached 4.5% strain will be used in describing the stress-strain response of multi-year ridge ice.

A statistical summary of the mechanical properties for each test condition is provided in Tables 7-10. The tables list the number of samples for each property along with the standard descriptive statistics of each sample population. A measure of kurtosis and skewness is included to give an impression of the shape of each distribution of the mechanical properties.

COMPARISON WITH CRREL'S RESULTS

The mean values of selected properties from Tables 7-10 are normalized by the corresponding mean values reported by Cox et al.[1] to provide a comparison of data sets. The ratios of mean values are listed in Table 11 and show good agreement between the data sets except for the initial tangent modulus at the low strain rate.

The discrepancy in modulus values can be attributed to different measuring techniques. The instrumentation of an ice sample provided two methods of measuring the axial displacement. One method employed two DCDTs

Table 3

MECHANICAL PROPERTIES
STRAIN RATE = (10E-5)/SEC   TEMPERATURE = -5°C

Ridge ID	σ_M	ϵ_M	σ_R	ϵ_E	E_T	E_S	σ_R/σ_M	FM	I_P	I_T	I_F	I_C	I_C/I_F
R1A-062/089	425.	.344	241.	4.84	0.965	0.123	0.566	31	1.20	13.0	10.8	2.19	0.202
R1B-062/089	321.	.463	205.	4.87	0.467	0.069	0.638	31	1.18	10.4	9.2	1.22	0.133
R2A-140/165	368.	.597	236.	4.85	0.493	0.062	0.643	30	1.80	12.8	10.6	2.24	0.212
R2B-094/121	167.	.142	174.	4.88	0.201	0.117	1.042	10	0.16	7.0	7.0	0.00	0.000
R3A-106/131	333.	.461	245.	4.84	0.330	0.072	0.736	30	1.26	12.4	10.9	1.47	0.134
R3B-161/187	300.	.335	201.	4.86	0.231	0.089	0.670	13	0.76	10.2	9.0	1.24	0.139
R4A-312/338	277.	.481	189.	4.86	0.482	0.058	0.681	30	1.11	9.7	8.5	1.23	0.145
R4B-328/354	244.	.497	156.	4.77	0.211	0.049	0.641	31	0.95	8.1	7.0	1.14	0.163
R5A-165/191	606.	.229	272.	4.87	1.041	0.265	0.449	13	1.00	15.3	12.2	3.10	0.254
R5B-075/101	755.	.219	241.	4.86	0.797	0.345	0.319	30	1.15	14.6	10.8	3.79	0.351
R7A-059/085	359.	.545	252.	4.86	0.488	0.066	0.702	30	1.58	12.8	11.3	1.53	0.135
R7B-126/152	239.	.452	206.	4.86	0.327	0.053	0.864	10	0.90	9.3	9.2	0.09	0.010
R8A-133/159	238.	.335	202.	4.85	0.450	0.071	0.848	13	0.66	9.2	9.0	0.16	0.017
R8B-162/189	324.	.433	224.	4.81	0.294	0.075	0.693	30	1.11	11.4	10.0	1.41	0.141
R3C-095/122	265.	.483	201.	4.87	0.177	0.055	0.759	30	1.00	9.6	8.9	0.67	0.075
R3D-159/186	201.	.841	198.	4.50	0.268	0.024	0.986	30	1.51	8.8	8.8	0.00	0.000
R5C-039/066	376.	.435	253.	4.88	0.689	0.086	0.675	30	1.39	13.1	11.3	1.76	0.155
R5D-159/186	359.	.599	230.	4.82	0.212	0.060	0.640	30	1.68	12.3	10.2	2.07	0.203
R6C-166/193	211.	.337	221.	4.88	0.314	0.063	1.045	10	0.58	9.4	9.4	0.00	0.000
R8C-048/075	228.	.234	169.	4.88	0.500	0.097	0.741	31	0.42	8.1	7.6	0.52	0.069
R8D-236/263	329.	.254	267.	4.88	0.441	0.130	0.812	30	0.65	12.0	11.9	0.07	0.006
R1A-226/252	208.	.204	113.	4.86	1.286	0.102	0.546	31	0.34	5.7	5.1	0.62	0.122
R1A-399/425	203.	.234	127.	4.88	1.056	0.087	0.625	13	0.40	6.6	5.7	0.89	0.156
R2A-205/230	403.	.461	.	2.90	0.584	0.087	.	0	1.46	.	.	.	.
R2A-314/339	313.	.257	163.	4.85	0.432	0.121	0.522	12	0.62	8.4	7.3	1.10	0.150
R2B-408/434	339.	.607	258.	4.85	0.466	0.056	0.762	13	1.73	12.8	11.5	1.26	0.109
R2B-468/494	259.	.380	194.	4.86	0.534	0.068	0.749	31	0.83	9.6	8.7	0.91	0.104

Table 3 (Cont'd.)

Ridge ID	σ_M	ϵ_M	σ_R	ϵ_E	E_T	E_S	σ_R/σ_M	FM	I_P	I_T	I_F	I_C	I_C/I_F
R3A-220/245	248.	.342	178.	4.81	0.183	0.073	0.716	31	0.64	8.6	7.9	0.68	0.085
R3A-430/456	301.	.463	208.	4.87	1.045	0.065	0.692	31	1.20	10.6	9.3	1.26	0.135
R3B-363/389	369.	.501	243.	4.86	0.499	0.074	0.658	30	1.56	12.7	10.9	1.82	0.168
R4A-426/452	318.	.312	176.	4.86	0.661	0.102	0.554	32	0.79	9.5	7.9	1.60	0.203
R4B-391/417	293.	.277	190.	4.85	0.708	0.106	0.648	31	0.67	9.4	8.5	0.88	0.103
R4B-449/475	244.	.355	166.	4.85	0.282	0.069	0.680	13	0.69	8.3	7.4	0.88	0.118
R5A-397/423	309.	.480	225.	4.80	0.135	0.064	0.729	10	1.05	11.3	9.9	1.36	0.137
R5A-442/468	451.	.253	209.	4.86	0.624	0.178	0.462	30	0.88	11.9	9.4	2.53	0.270
R5A-504/530	319.	.493	220.	4.78	0.232	0.065	0.692	30	1.25	11.0	9.8	1.20	0.123
R5B-341/367	361.	.553	.	4.13	0.469	0.065	.	31	1.62	.	.	.	.
R5B-398/423	294.	.407	229.	4.78	0.344	0.072	0.779	13	0.95	11.3	10.2	1.07	0.105
R7A-263/289	71.	.078	59.	4.86	0.234	0.091	0.841	31	0.04	2.6	2.6	0.00	0.000
R7A-342/368	553.	.218	160.	4.83	0.542	0.254	0.289	32	0.86	9.4	7.2	2.22	0.310
R7B-241/267	226.	.448	161.	4.86	0.185	0.050	0.714	30	0.80	7.8	7.2	0.63	0.087
R8A-164/190	259.	.242	176.	4.85	0.387	0.107	0.679	10	0.50	8.4	7.9	0.52	0.066
R8A-432/458	631.	.169	199.	4.84	0.866	0.372	0.315	13	0.77	11.2	8.9	2.27	0.254
R8B-333/359	335.	.253	206.	4.86	0.936	0.132	0.615	30	0.66	10.6	9.2	1.35	0.146
R8B-515/541	338.	.416	219.	4.95	0.449	0.081	0.647	30	1.14	11.5	9.8	1.70	0.173
R3C-296/323	290.	.610	.	1.23	0.412	0.048	.	30	1.51	.	.	.	.
R3C-380/407	186.	.210	127.	4.87	0.278	0.089	0.681	10	0.31	6.0	5.7	0.31	0.055
R3D-219/246	252.	.341	186.	4.87	0.316	0.074	0.739	30	0.69	8.9	8.3	0.58	0.070
R3D-287/314	334.	.659	251.	4.88	0.328	0.051	0.752	30	1.87	12.7	11.2	1.50	0.134
R5C-219/246	290.	.487	197.	4.72	0.248	0.059	0.679	30	1.13	10.2	8.8	1.41	0.161
R5C-282/309	257.	.508	189.	4.88	0.295	0.051	0.733	31	1.08	9.3	8.4	0.86	0.101
R5D-225/252	368.	.508	235.	4.88	0.387	0.072	0.640	30	1.51	12.4	10.5	1.90	0.181
R5D-294/321	325.	.498	208.	4.88	0.461	0.065	0.640	31	1.33	11.2	9.3	1.89	0.203
R6A-562/589	219.	.479	176.	4.88	0.327	0.046	0.804	30	0.89	8.4	7.9	0.53	0.067

Table 3 (Cont'd.)

Ridge ID	σ_M	ϵ_M	σ_R	ϵ_E	E_T	E_S	σ_R/σ_M	FM	I_P	I_T	I_F	I_C	I_C/I_F
R6C-529/556	368.	.811	272.	4.88	1.039	0.045	0.740	30	2.55	14.0	12.2	1.80	0.147
R8C-378/405	775.	.239	207.	4.87	0.762	0.324	0.267	13	1.32	13.9	9.3	4.61	0.497
R8C-476/503	137.	.214	82.	4.65	0.190	0.064	0.595	10	0.22	4.0	3.7	0.33	0.089
R8D-446/473	217.	.211	.	4.30	0.376	0.103	.	10	0.36	.	.	.	.
R8D-534/561	241.	.200	123.	4.88	0.312	0.120	0.511	30	0.37	7.0	5.5	1.49	0.270
R9A-341/368	265.	.488	182.	4.60	0.645	0.054	0.689	30	1.10	9.5	8.2	1.34	0.164
R9B-385/412	289.	.701	.	1.86	0.380	0.041	.	30	1.75	.	.	.	.
R9C-426/453	284.	.468	216.	4.50	0.446	0.061	0.761	30	1.12	10.3	9.7	0.63	0.065
R9D-181/208	254.	.299	.	4.40	2.498	0.085	.	13	0.62	.	.	.	.
R10A-351/378	348.	.685	258.	4.92	0.539	0.051	0.742	30	2.05	13.5	11.5	1.95	0.169
R10B-351/378	313.	.415	240.	4.88	0.658	0.075	0.767	10	1.08	11.7	10.8	0.94	0.088
R10C-316/343	253.	.366	179.	4.88	0.346	0.069	0.710	30	0.75	8.8	8.0	0.79	0.099
R10D-325/352	346.	.317	205.	4.87	0.341	0.109	0.593	31	0.85	10.9	9.2	1.74	0.190

Table 4

MECHANICAL PROPERTIES
STRAIN RATE = (10E-5)/SEC TEMPERATURE = -20°C

Ridge ID	σ_M	ϵ_M	σ_R	ϵ_E	E_T	E_S	σ_R/σ_M	FM	I_P	I_T	I_F	I_C	I_C/I_F
R1C-065/092	574.	.181	209.	4.88	2.364	0.318	0.364	0	0.77	12.2	9.4	2.80	0.298
R1D-071/098	622.	.205	195.	4.88	1.164	0.304	0.313	10	0.91	12.3	8.8	3.54	0.404
R3C-128/155	429.	.332	307.	4.87	0.457	0.129	0.717	31	1.12	15.1	13.7	1.39	0.101
R3D-129/156	291.	.249	243.	4.87	0.392	0.117	0.835	31	0.57	10.9	10.9	0.04	0.004
R5C-097/124	348.	.353	.	3.67	0.305	0.099	.	0	0.97	.	.	.	.
R5D-121/148	412.	.234	275.	4.88	0.848	0.176	0.668	13	0.76	13.2	12.3	0.87	0.071
R6A-461/488	330.	.279	220.	4.65	0.447	0.118	0.666	31	0.73	10.9	9.8	1.05	0.107
R8C-165/192	518.	.324	323.	4.97	0.568	0.160	0.624	13	1.33	16.4	14.4	1.96	0.135
R8D-192/219	475.	.244	289.	4.88	0.909	0.195	0.609	13	0.95	14.8	13.0	1.84	0.142
R9A-125/152	365.	.474	356.	4.88	0.564	0.077	0.976	13	1.54	15.5	15.5	0.00	0.000
R9B-043/070	338.	.435	304.	4.88	0.966	0.078	0.899	31	1.29	13.8	13.6	0.17	0.012
R10A-195/222	312.	.268	213.	4.96	0.400	0.116	0.681	30	0.65	10.8	9.5	1.27	0.133
R10D-157/184	369.	.474	275.	4.60	0.493	0.078	0.745	30	1.46	13.7	12.3	1.40	0.114
R1C-210/236	385.	.257	209.	4.84	0.408	0.150	0.545	13	0.73	11.1	9.4	1.75	0.187
R1C-240/266	451.	.225	262.	4.89	2.312	0.200	0.581	0	0.88	13.9	11.8	2.12	0.180
R1D-209/236	534.	.210	237.	4.78	0.633	0.254	0.445	12	0.81	13.6	10.6	2.98	0.281
R1D-315/342	229.	.258	131.	4.95	0.521	0.089	0.569	31	0.49	7.0	5.9	1.12	0.191
R3C-329/359	426.	.444	.	4.19	0.471	0.096	.	10	1.61	.	.	.	.
R3C-411/438	169.	.231	.	4.19	0.241	0.073	.	13	0.31	.	.	.	.
R3D-250/277	440.	.341	315.	4.87	0.381	0.129	0.716	30	1.16	15.5	14.0	1.46	0.104
R3D-318/345	454.	.522	332.	4.87	0.442	0.087	0.732	30	1.98	16.8	14.8	1.98	0.134
R5C-250/277	485.	.397	.	1.80	0.421	0.122	.	32	1.47	.	.	.	.
R5C-328/355	390.	.303	194.	4.88	2.768	0.129	0.498	0	0.96	10.9	8.7	2.18	0.250
R5D-255/282	390.	.469	281.	4.88	0.397	0.083	0.721	0	1.49	14.0	12.5	1.45	0.116
R5D-325/352	462.	.410	278.	4.88	0.436	0.113	0.602	0	1.50	14.6	12.4	2.18	0.175
R6A-661/688	271.	.253	.	1.45	0.425	0.107	.	13	0.55	.	.	.	.
R6C-589/616	398.	.277	.	2.28	0.817	0.144	.	30	0.89	.	.	.	.

Table 4 (Cont'd.)

Ridge ID	σ_M	ϵ_M	σ_R	ϵ_R	E_T	E_S	σ_R/σ_M	FM	I_P	I_T	I_F	I_C	I_C/I_F
R8C-444/471	391.	.276	.	2.48	0.546	0.142	.	12	0.86	.	.	.	.
R8C-508/535	241.	.189	94.	4.97	0.347	0.127	0.389	31	0.34	5.6	4.2	1.38	0.328
R8D-477/504	173.	.318	119.	4.88	0.331	0.055	0.684	12	0.47	6.5	5.3	1.17	0.219
R8D-565/592	389.	.239	191.	4.88	0.610	0.162	0.492	30	0.70	10.3	8.6	1.73	0.203
R9A-523/550	419.	.400	.	3.88	0.509	0.105	.	13	1.45	.	.	.	.
R9B-449/476	297.	.308	209.	4.88	0.440	0.096	0.706	31	0.77	10.1	9.4	0.74	0.080
R9C-395/422	421.	.346	272.	4.87	0.735	0.121	0.645	30	1.28	14.2	12.2	2.01	0.165
R9D-317/344	362.	.381	236.	4.88	0.504	0.095	0.653	30	1.21	12.1	10.6	1.54	0.145
R10A-320/347	457.	.253	220.	4.87	0.533	0.180	0.482	13	0.87	11.6	9.9	1.75	0.177
R10B-418/445	536.	.573	427.	4.85	0.423	0.093	0.797	30	2.59	20.9	19.0	1.90	0.100

Table 5

MECHANICAL PROPERTIES
STRAIN RATE = (10E-3)/SEC TEMPERATURE = -5°C

Ridge ID	σ_M	ε_M	σ_R	ε_E	E_T	E_S	σ_R/σ_M	FM	I_P	I_T	I_F	I_C	I_C/I_F
R1A-175/201	1225.	.122	.	1.77	1.507	1.003	.	0	0.97	.	.	.	.
R1B-131/157	1222.	.211	172.	4.90	0.883	0.579	0.141	31	1.64	17.4	7.7	9.68	1.253
R2A-110/135	403.	.036	.	0.04	1.275	1.123	.	20	0.07	.	.	.	.
R2B-135/161	842.	.093	.	0.09	1.222	0.908	.	23	0.45	.	.	.	.
R3A-188/213	927.	.140	203.	4.98	1.089	0.664	0.219	31	0.86	15.2	9.1	6.08	0.667
R3B-130/155	870.	.123	245.	4.90	1.140	0.709	0.281	30	0.71	15.0	11.0	4.00	0.364
R4A-283/309	893.	.098	.	0.10	1.179	0.911	.	23	0.52	.	.	.	.
R4B-299/325	885.	.126	103.	4.86	1.016	0.700	0.117	30	0.71	10.5	4.6	5.87	1.268
R5A-135/161	1123.	.078	.	0.08	1.877	1.446	.	23	0.50	.	.	.	.
R5B-141/167	1288.	.122	.	0.12	1.205	1.052	.	23	0.85	.	.	.	.
R7A-005/031	757.	.107	.	0.11	0.846	0.705	.	23	0.45	.	.	.	.
R7B-072/098	510.	.106	.	0.11	1.823	0.481	.	23	0.44	.	.	.	.
R8A-033/059	357.	.075	.	0.08	0.474	0.474	.	23	0.13	.	.	.	.
R8B-011/037	761.	.069	.	0.07	1.203	1.102	.	20	0.28	.	.	.	.
R2C-049/076	654.	.145	159.	4.98	0.643	0.452	0.243	31	0.60	10.2	7.1	3.06	0.430
R2D-134/161	733.	.149	155.	4.98	0.708	0.490	0.212	31	0.70	11.5	7.0	4.54	0.653
R4C-244/271	788.	.092	.	0.09	0.870	0.857	.	20	0.37	.	.	.	.
R4C-309/336	847.	.209	208.	4.98	0.670	0.405	0.245	30	1.18	14.8	9.3	5.47	0.587
R4D-228/255	624.	.067	.	0.07	1.007	0.933	.	20	0.22	.	.	.	.
R7C-007/034	910.	.093	.	0.09	1.466	0.980	.	23	0.52	.	.	.	.
R6A-398/425	789.	.135	107.	4.99	0.929	0.585	0.135	32	0.68	9.7	4.8	4.89	1.017
R6A-504/531	829.	.175	217.	4.99	0.717	0.474	0.262	30	0.90	14.6	9.7	4.87	0.500
R7D-088/114	1014.	.160	221.	5.00	1.772	0.633	0.218	30	1.16	16.8	9.9	6.87	0.692
R9C-080/107	902.	.185	256.	4.99	0.833	0.488	0.283	31	1.09	16.4	11.5	4.92	0.428
R9D-082/109	847.	.160	102.	5.00	0.791	0.529	0.121	10	0.85	10.3	4.6	5.72	1.247
R1A-300/326	1594.	.136	.	0.14	1.302	1.175	.	20	1.14	.	.	.	.
R1B-216/241	856.	.149	179.	4.95	0.953	0.576	0.210	13	0.84	13.7	8.0	5.66	0.704

Table 5 (Cont'd.)

Ridge ID	σ_M	ϵ_M	σ_R	ϵ_E	E_T	E_S	σ_R/σ_M	FM	I_P	I_T	I_F	I_C	I_C/I_F
R1B-243/268	982.	.122	148.	4.88	1.257	0.804	0.150	32	0.78	12.7	6.7	6.05	0.909
R2A-285/310	1244.	.193	102.	4.95	1.008	0.644	0.082	32	1.55	14.7	4.6	10.12	2.206
R2A-383/408	1043.	.096	.	0.10	1.400	1.085	.	20	0.58	.	.	.	.
R2B-351/377	1156.	.118	.	0.12	1.283	0.977	.	12	0.81	.	.	.	.
R2B-438/464	969.	.152	144.	4.88	1.024	0.640	0.149	30	0.96	13.7	6.5	7.23	1.118
R3A-401/427	890.	.123	160.	4.93	1.248	0.721	0.179	13	0.75	13.3	7.2	6.11	0.850
R3B-239/265	834.	.133	255.	4.91	1.007	0.628	0.306	30	0.74	16.9	11.4	5.46	0.477
R3B-331/357	940.	.152	209.	4.91	1.073	0.617	0.222	32	0.97	16.9	9.4	7.52	0.801
R4A-398/423	754.	.161	134.	4.89	0.734	0.467	0.178	30	0.80	11.9	6.0	5.88	0.977
R4B-358/384	750.	.142	95.	4.88	0.859	0.530	0.127	32	0.71	10.4	4.3	6.13	1.436
R4B-420/446	949.	.165	.	0.18	1.067	0.575	.	10	1.03	.	.	.	.
R5A-473/499	846.	.144	178.	4.97	0.953	0.586	0.211	13	0.82	14.3	8.0	6.31	0.789
R5B-287/313	1045.	.093	.	0.10	1.391	1.121	.	20	0.56	.	.	.	.
R5B-370/396	793.	.130	145.	4.99	0.976	0.611	0.183	31	0.68	12.6	6.5	6.09	0.934
R7A-232/258	723.	.145	134.	4.99	0.656	0.499	0.185	30	0.64	10.0	6.0	3.98	0.662
R7A-295/321	642.	.133	.	0.18	0.950	0.484	.	20	0.60	.	.	.	.
R7B-175/201	574.	.033	.	0.03	1.830	1.724	.	10	0.10	.	.	.	.
R7B-440/466	1491.	.158	.	0.16	1.169	0.941	.	23	1.35	.	.	.	.
R8A-305/331	590.	.113	243.	4.90	0.916	0.523	0.413	30	0.45	13.8	10.9	2.90	0.266
R8A-384/410	1312.	.157	.	0.16	1.329	0.833	.	10	1.33	.	.	.	.
R8B-300/326	554.	.260	241.	4.90	0.531	0.213	0.436	30	1.10	14.5	10.8	3.71	0.344
R8B-483/509	1450.	.360	.	0.37	1.100	0.403	.	23	3.98	.	.	.	.
R2C-196/223	862.	.145	187.	4.99	0.804	0.594	0.217	31	0.71	13.2	8.4	4.81	0.573
R2C-278/305	691.	.174	199.	4.97	0.618	0.396	0.287	31	0.79	13.1	8.9	4.18	0.468
R2D-220/247	790.	.133	.	0.14	0.868	0.594	.	12	0.65	.	.	.	.
R2D-334/371	752.	.165	126.	4.99	0.657	0.456	0.168	13	0.75	10.3	5.7	4.64	0.820
R4C-414/441	740.	.152	211.	4.88	0.854	0.488	0.285	30	0.74	13.4	9.5	3.93	0.415

Table 5 (Cont'd.)

Ridge ID	σ_M	ε_M	σ_R	ε_E	E_T	E_S	σ_R/σ_M	FM	I_P	I_T	I_F	I_C	I_C/I_F
R4C-512/539	841.	.139	86.	4.63	1.011	0.605	0.103	10	0.78	10.9	3.9	7.03	1.819
R4D-495/522	631.	.141	.	3.35	0.704	0.448	.	20	0.57	.	.	.	.
R6C-476/503	864.	.170	160.	4.99	0.752	0.509	0.185	13	0.94	13.3	7.2	6.12	0.852
R7C-143/170	1029.	.220	282.	4.78	0.749	0.467	0.274	30	1.48	19.8	12.6	7.16	0.567
R7C-541/568	1001.	.154	176.	4.98	1.035	0.648	0.176	30	1.00	15.0	7.9	7.09	0.898
R7D-223/250	938.	.235	240.	4.89	0.632	0.400	0.256	30	1.44	17.8	10.8	7.05	0.655
R7D-312/339	994.	.165	236.	5.00	0.867	0.602	0.238	30	1.01	17.0	10.6	6.41	0.606
R9A-445/482	643.	.149	89.	4.97	0.685	0.431	0.139	13	0.64	8.8	4.0	4.80	1.200
R9B-329/356	788.	.089	.	0.09	1.193	0.881	.	20	0.40	.	.	.	.
R9C-332/359	695.	.195	155.	4.99	0.584	0.356	0.223	30	0.90	11.8	7.0	4.85	0.697
R9D-249/276	770.	.170	101.	4.98	0.687	0.454	0.131	13	0.84	9.8	4.5	5.26	1.160
R10A-269/296	987.	.180	287.	5.00	0.947	0.548	0.290	13	1.16	19.2	12.9	6.33	0.492
R10B-274/301	974.	.174	265.	4.84	0.932	0.558	0.272	0	1.10	18.4	11.9	6.51	0.548
R10C-445/472	836.	.117	.	0.12	1.098	0.718	.	21	0.62	.	.	.	.
R10D-231/258	903.	.175	136.	4.99	0.874	0.516	0.150	31	1.02	13.4	6.1	7.29	1.193

Table 6

MECHANICAL PROPERTIES
STRAIN RATE = (10E-3)/SEC TEMPERATURE = -20°C

Ridge ID	σ_M	ϵ_M	σ_R	ϵ_E	E_T	E_S	σ_R/σ_M	FM	I_P	I_T	I_F	I_C	I_C/I_F
R1C-127/154	1513.	.162	.	0.16	1.227	0.935	.	0	1.39	.	.	.	.
R1D-153/178	1240.	.098	.	0.10	1.395	1.267	.	23	0.64	.	.	.	.
R2C-129/156	1576.	.227	.	0.23	0.793	0.695	.	23	1.96	.	.	.	.
R2D-095/122	1266.	.134	.	0.13	1.208	0.945	.	21	0.98	.	.	.	.
R4D-198/225	1174.	.119	.	0.12	1.040	0.988	.	20	0.72	.	.	.	.
R6A-531/558	1217.	.158	212.	4.79	1.489	0.770	0.174	30	1.33	18.1	9.5	8.58	0.900
R6C-134/161	1322.	.158	.	0.16	1.129	0.836	.	12	1.24	.	.	.	.
R7C-092/119	1801.	.237	.	1.64	1.207	0.761	.	23	2.77	.	.	.	.
R7D-036/063	1734.	.232	.	0.23	1.075	0.747	.	23	2.44	.	.	.	.
R9A-071/098	1238.	.225	.	2.61	0.809	0.550	.	12	1.75	.	.	.	.
R9B-076/103	1134.	.240	97.	4.99	0.751	0.473	0.085	13	1.70	16.5	4.4	12.14	2.786
R9C-049/076	1509.	.269	295.	4.98	0.925	0.560	0.195	31	2.64	23.6	13.2	10.37	0.784
R9D-150/177	1592.	.224	259.	4.98	1.310	0.710	0.163	31	2.41	22.5	11.6	10.87	0.935
R10A-238/265	1825.	.330	.	0.43	0.884	0.553	.	23	3.94	.	.	.	.
R10B-084/111	1493.	.209	233.	4.98	1.392	0.713	0.156	31	2.12	24.4	10.5	13.93	1.331
R1C-349/375	1450.	.168	.	0.17	1.567	0.865	.	20	1.61	.	.	.	.
R1C-384/410	1013.	.095	.	0.10	1.377	1.061	.	20	0.55	.	.	.	.
R1D-179/206	1638.	.162	.	0.16	1.179	1.009	.	20	1.45	.	.	.	.
R1D-285/312	1625.	.110	.	0.11	1.706	1.474	.	20	0.96	.	.	.	.
R2C-226/253	1510.	.249	220.	4.98	0.844	0.606	0.146	13	2.33	20.1	9.9	10.23	1.036
R2C-310/337	1082.	.272	.	1.64	0.692	0.398	.	32	1.98	.	.	.	.
R2D-265/292	1407.	.193	.	0.19	0.919	0.728	.	10	1.55	.	.	.	.
R2D-406/433	1122.	.234	126.	4.98	0.719	0.479	0.112	31	1.68	15.3	5.7	9.64	1.704
R4C-482/509	1449.	.220	321.	4.88	1.068	0.659	0.222	30	2.09	24.3	14.4	9.90	0.688
R4C-543/570	1433.	.278	.	4.41	0.795	0.516	.	31	2.54	.	.	.	.
R4D-382/409	1457.	.274	292.	4.98	0.803	0.531	0.201	31	2.52	24.6	13.1	11.51	0.880
R4D-414/441	1345.	.136	.	0.14	1.461	0.990	.	12	1.12	.	.	.	.

Table 6 (Cont'd.)

Ridge ID	σ_M	ε_M	σ_R	ε_E	E_T	E_S	σ_R/σ_M	FM	I_P	I_T	I_F	I_C	I_C/I_F
R4D-525/552	1327.	.229	.	0.23	0.887	0.579	.	10	1.89	.	.	.	.
R6C-559/586	1449.	.255	239.	4.80	1.043	0.569	0.165	30	2.47	22.5	10.7	11.77	1.097
R7C-457/484	1669.	.305	187.	4.99	0.848	0.548	0.112	31	3.31	25.3	8.4	16.91	2.014
R7C-572/599	1784.	.264	.	0.28	1.058	0.676	.	20	3.01	.	.	.	.
R7D-254/281	1323.	.294	375.	4.98	0.702	0.450	0.284	31	2.52	26.0	16.8	9.23	0.550
R7D-546/573	1503.	.240	266.	4.98	0.959	0.627	0.177	32	2.27	23.7	11.9	11.77	0.986
R9A-424/451	1161.	.162	.	0.16	0.949	0.716	.	12	1.10	.	.	.	.
R9B-417/444	1411.	.250	.	0.25	0.861	0.565	.	12	2.15	.	.	.	.
R9C-507/534	1374.	.199	334.	4.98	1.129	0.689	0.243	30	1.78	22.1	15.0	7.12	0.475
R9D-348/375	1187.	.035	.	0.04	4.607	3.364	.	20	0.24	.	.	.	.
R10A-407/434	1462.	.269	391.	4.88	0.797	0.545	0.268	30	2.47	28.8	17.5	11.30	0.646
R10B-449/476	1466.	.230	282.	4.99	0.919	0.639	0.192	30	2.11	22.2	12.6	9.55	0.755
R10C-506/533	1235.	.225	241.	4.99	0.758	0.549	0.195	31	1.70	20.9	10.8	10.09	0.934
R10D-508/535	1315.	.199	228.	4.98	1.249	0.660	0.173	30	1.78	21.4	10.2	11.16	1.090

Table 7

STATISTICAL SUMMARY OF MECHANICAL PROPERTIES

STRAIN RATE = (10E-5)/SEC TEMPERATURE = -5°C

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Kurtosis	Skewness	Variance	C.V.
σ_M	67	316.134	122.220	71.000	775.000	21181.000	4.940	1.853	14937.694	38.661
ε_M	67	0.400	0.161	0.078	0.841	26.833	0.032	0.457	0.026	40.109
σ_R	61	199.918	44.081	59.000	272.000	12195.000	1.196	-0.864	1943.110	22.049
E_T	67	0.509	0.356	0.135	2.498	34.101	14.054	3.039	0.127	69.890
E_S	67	0.094	0.069	0.024	0.372	6.326	7.527	2.744	0.005	72.737
σ_R/σ_M	61	0.674	0.151	0.267	1.045	41.107	1.746	-0.452	0.023	22.449
I_P	67	1.014	0.488	0.040	2.550	67.960	0.416	0.492	0.238	48.115
I_T	61	10.187	2.500	2.600	15.300	621.400	0.635	-0.518	6.250	24.542
I_F	61	8.920	1.973	2.600	12.200	544.100	1.158	-0.840	3.893	22.120
I_C	61	1.266	0.887	0.000	4.610	77.250	2.898	1.224	0.787	70.053
I_C/I_F	61	0.138	0.089	0.000	0.497	8.418	3.569	1.228	0.008	64.622

Table 8

STATISTICAL SUMMARY OF MECHANICAL PROPERTIES

STRAIN RATE = (10E-5)/SEC TEMPERATURE = -20°C

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Kurtosis	Skewness	Variance	C.V.
σ_M	37	393.324	102.714	169.000	622.000	14553.000	0.179	-0.186	10550.170	26.114
ϵ_M	37	0.322	0.100	0.181	0.573	11.932	-0.263	0.740	0.010	30.934
σ_R	29	248.828	71.723	94.000	427.000	7216.000	0.587	0.038	5144.219	28.824
E_T	37	0.690	0.576	0.241	2.768	25.528	6.745	2.690	0.332	83.532
E_S	37	0.133	0.060	0.055	0.318	4.917	2.959	1.676	0.004	44.852
σ_R/σ_M	29	0.633	0.154	0.313	0.976	18.354	0.118	-0.066	0.024	24.257
I_P	37	1.038	0.473	0.310	2.590	38.420	1.880	1.060	0.224	45.546
I_T	29	12.700	3.205	5.600	20.900	368.300	1.013	-0.102	10.271	25.235
I_F	29	11.121	3.163	4.200	19.000	322.500	0.641	-0.008	10.003	28.440
I_C	29	1.578	0.802	0.000	3.540	45.770	0.716	0.098	0.643	50.808
I_C/I_F	29	0.157	0.093	0.000	0.404	4.556	0.778	0.641	0.009	59.307

Table 9

STATISTICAL SUMMARY OF MECHANICAL PROPERTIES

STRAIN RATE = (10E-3)/SEC   TEMPERATURE = -5°C

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Kurtosis	Skewness	Variance	C.V.
σ_M	69	879.855	234.395	357.000	1594.000	60710.000	1.230	0.724	54941.008	26.640
ϵ_M	69	0.143	0.050	0.033	0.360	9.886	4.566	1.099	0.002	34.894
σ_R	42	177.405	57.305	86.000	287.000	7451.000	-1.028	0.145	3283.808	32.302
E_T	69	1.010	0.312	0.474	1.877	69.712	0.786	0.888	0.098	30.919
E_S	69	0.677	0.271	0.213	1.724	46.729	2.640	1.439	0.073	39.961
σ_R/σ_M	42	0.212	0.076	0.082	0.436	8.902	1.196	0.846	0.006	35.856
I_P	69	0.836	0.507	0.070	3.980	57.660	21.329	3.575	0.257	60.618
I_T	42	13.738	2.821	8.800	19.800	577.000	-0.684	0.242	7.956	20.531
I_F	42	7.964	2.564	3.900	12.900	334.500	-1.026	0.145	6.574	32.192
I_C	42	5.776	1.501	2.900	10.120	242.580	1.267	0.622	2.254	25.991
I_C/I_F	42	0.822	0.400	0.266	2.206	34.542	2.617	1.390	0.160	48.639

Table 10

STATISTICAL SUMMARY OF MECHANICAL PROPERTIES

STRAIN RATE = (10E-3)/SEC TEMPERATURE = -20°C

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Kurtosis	Skewness	Variance	C.V.
σ_M	41	1410.512	201.908	1013.000	1825.000	57831.000	-0.470	0.188	40766.906	14.315
ϵ_M	41	0.209	0.064	0.035	0.330	8.569	0.127	-0.619	0.004	30.633
σ_R	18	255.444	76.039	97.000	391.000	4598.000	0.255	-0.231	5781.908	29.767
E_T	41	1.135	0.614	0.692	4.607	46.530	26.606	4.727	0.377	54.079
E_S	41	0.780	0.470	0.398	3.364	31.995	23.488	4.415	0.221	60.244
σ_R/σ_M	18	0.181	0.052	0.085	0.284	3.263	0.060	0.200	0.003	28.668
I_P	41	1.883	0.770	0.240	3.940	77.210	0.292	0.139	0.593	40.895
I_T	18	22.350	3.345	15.300	28.800	402.300	0.433	-0.474	11.192	14.968
I_F	18	11.456	3.392	4.400	17.500	206.200	0.244	-0.221	11.505	29.609
I_C	18	10.893	2.131	7.120	16.910	196.070	3.077	1.179	4.542	19.564
I_C/I_F	18	1.088	0.571	0.475	2.786	19.591	3.882	1.886	0.326	52.460

Table 11

COMPARISON OF MEAN VALUES

	Test Conditions			
	C55	C520	C35	C320
σ_M	.929	.973	1.001	1.011
ε_M	1.053	1.039	1.100	1.100
σ_R/σ_M	.980	.986	.933	1.071
E_T	.687	.775	.985	.948

NOTE: Numbers indicate mean values reported here normalized by mean values reported in (1).

with a gage length of 5 1/2 inches mounted 180° apart on the ice; the other method employed an extensometer with a full sample gage length of 10 inches. Cox et al.[1] measured the initial tangent modulus by graphically measuring the slope of the force-displacement curve where the displacement was taken as the average output of the two DCDTs. This technique has an advantage since it provides a measurement from transducers mounted directly on the ice. However, due to the nonhomogeneous deformation of the ice samples, the DCDTs were only reliable to approximately 0.1% strain. We were interested in studying the stress-strain curve well beyond 0.1% strain. Since the extensometer was used as the control for the test and its output was proportional to time, we chose to calculate the initial tangent modulus by measuring the maximum slope of the force-time curve. These measurements would then be consistent with the stress-strain curve up to 5% strain. Despite the disagreement between the mean modulus values, the discrepancy is within the scatter of the data so that one data set should not be preferred over the other.

TEMPERATURE AND STRAIN RATE EFFECTS ON THE MECHANICAL PROPERTIES

The standard procedure for studying the effects of temperature and strain rate on the mechanical properties would be to conduct an analysis of the variance of each property over the four test conditions. Since the sample populations are unequal for each test condition, this type of analysis would be a lengthy and time consuming procedure that is beyond the scope of this study. Instead, meaningful conclusions about the effects of temperature and strain rate can be drawn by comparison of mean values of a particular property for different pairs of test conditions. Four pairs of test conditions are chosen for comparison. Two pairs represent the two levels of constant temperature and two pairs represent the two levels of constant strain rate.

In most cases, it is obvious from the data and our experience how a mechanical property will vary with temperature or strain rate. However, in cases where experience offers no guidance or when the mean values of the two samples are fairly close and the variances are large, it is difficult to draw a conclusion. In these cases, it is necessary to have an objective method of comparing the mean values. A statistic commonly used to compare mean values is the t-statistic defined by,

$$t = \frac{\bar{X}_a - \bar{X}_b}{s_d} \quad .$$

Here $\bar{X}_a$ and $\bar{X}_b$ are the mean values of the two samples being compared and s_d^2 is the estimated variance of $\bar{X}_a - \bar{X}_b$. The quantity s_d^2 depends on the variance and size of each sample.

The t-statistic is used in the t-test to make inferences about the relative values of the population means, μ_a and μ_b. The first step in conducting a t-test consists of stating an alternative to the null hypothesis, $\mu_a = \mu_b$. The alternative hypothesis is either $\mu_a < \mu_b$, $\mu_a > \mu_b$, or $\mu_a \neq \mu_b$. Once the alternative hypothesis is stated, a confidence limit is chosen which defines the critical region. If the t-statistic falls into the critical region, then the null hypothesis is rejected and the alternative hypothesis is accepted.

A t-test was conducted for each mechanical property for four pairs of test conditions. Table 12 summarizes the t-tests for the two pairs of test conditions with constant strain rate and Table 13 summarizes the t-tests for the two pairs of constant temperature. For each t-test, the alternative hypothesis was chosen by looking at the means and standard deviations of the two quantities being compared. If the means are within the standard deviation of each other, then $\mu_a \neq \mu_b$ is chosen as the alternative hypothesis. If the mean of one quantity is not within the standard deviation of the mean of the other quantity or vice-versa, then the appropriate inequality is chosen for the alternative. It is obvious from the choice of the alternative hypothesis whether a one or two tailed t-test is conducted. In every test, the null hypothesis was tested at the 99% confidence level.

It should be emphasized that the t-tests are only used as an aid in drawing conclusions about the effects of temperature and strain rate and should not be held sacred. It is quite possible that some results from the t-tests are contradictory and perhaps even offend our physical intuition. In these cases, judgment should be exercised before accepting or rejecting the t-test. The degree of confidence we have in the t-test depends on how well the fundamental assumptions of the t-test are satisfied. The most restrictive of these is the assumption that the variances of the two samples being compared are equal. This assumption can be relaxed by using an approximate t-statistic which assumes unequal variances. The statistical package used to calculate the t-statistic in Tables 12 and 13 also calculates the approximate

Table 12

PAIRWISE t-TESTS
STRAIN RATE CONSTANT; TEMPERATURE VARIES

Mechanical Property	Alternative Hypothesis	Critical Region	t	Conclusion (99% Confidence)
σ_M	$\mu_{C520} > \mu_{C55}$	$t > 2.37$	3.26	$\mu_{C520} > \mu_{C55}$
	$\mu_{C320} > \mu_{C35}$	$t > 2.36$	12.07	$\mu_{C320} > \mu_{C35}$
ε_M	$\mu_{C520} < \mu_{C55}$	$t < -2.37$	-2.68	$\mu_{C520} < \mu_{C55}$
	$\mu_{C320} > \mu_{C35}$	$t > 2.36$	5.99	$\mu_{C320} > \mu_{C35}$
σ_R	$\mu_{C520} > \mu_{C55}$	$t > 2.38$	3.98	$\mu_{C520} > \mu_{C55}$
	$\mu_{C320} > \mu_{C35}$	$t > 2.39$	4.37	$\mu_{C320} > \mu_{C35}$
E_T	$\mu_{C520} \neq \mu_{C55}$	$\lvert t\rvert > 2.64$	1.98	$\mu_{C520} = \mu_{C55}$
	$\mu_{C320} \neq \mu_{C35}$	$\lvert t\rvert > 2.63$	1.41	$\mu_{C320} = \mu_{C35}$
E_S	$\mu_{C520} \neq \mu_{C55}$	$\lvert t\rvert > 2.64$	2.86	$\mu_{C520} \neq \mu_{C55}$
	$\mu_{C320} \neq \mu_{C35}$	$\lvert t\rvert > 2.63$	1.46	$\mu_{C320} = \mu_{C35}$
σ_R/σ_M	$\mu_{C520} \neq \mu_{C55}$	$\lvert t\rvert > 2.64$	-1.20	$\mu_{C520} = \mu_{C55}$
	$\mu_{C320} \neq \mu_{C35}$	$\lvert t\rvert > 2.61$	-1.56	$\mu_{C320} = \mu_{C35}$
I_P	$\mu_{C520} \neq \mu_{C55}$	$\lvert t\rvert > 2.64$	.243	$\mu_{C520} = \mu_{C55}$
	$\mu_{C320} > \mu_{C35}$	$t > 2.36$	8.60	$\mu_{C320} > \mu_{C35}$
I_T	$\mu_{C520} > \mu_{C55}$	$t > 2.38$	4.06	$\mu_{C520} > \mu_{C55}$
	$\mu_{C320} > \mu_{C35}$	$t > 2.39$	10.24	$\mu_{C320} > \mu_{C35}$
I_F	$\mu_{C520} > \mu_{C55}$	$t > 2.38$	4.04	$\mu_{C520} > \mu_{C55}$
	$\mu_{C320} > \mu_{C35}$	$t > 2.39$	4.38	$\mu_{C320} > \mu_{C35}$

Table 12 Cont.

Mechanical Property	Alternative Hypothesis	Critical Region	t	Conclusion (99% Confidence)
I_C	$\mu_{C520} \neq \mu_{C55}$	$\lvert t \rvert > 2.64$	1.61	$\mu_{C520} = \mu_{C55}$
	$\mu_{C320} > \mu_{C35}$	$t > 2.39$	10.62	$\mu_{C320} > \mu_{C35}$
I_C/I_F	$\mu_{C520} \neq \mu_{C55}$	$\lvert t \rvert > 2.64$	0.94	$\mu_{C520} = \mu_{C55}$
	$\mu_{C320} \neq \mu_{C35}$	$\lvert t \rvert > 2.61$	2.07	$\mu_{C320} = \mu_{C35}$

Table 13

PAIRWISE t-TESTS
TEMPERATURE CONSTANT; STRAIN RATE VARIES

Mechanical Property	Alternative Hypothesis	Critical Region	t	Conclusion (99% Confidence)
σ_M	$\mu_{C35} > \mu_{C55}$	$t > 2.36$	17.51	$\mu_{C35} > \mu_{C55}$
	$\mu_{C320} > \mu_{C520}$	$t > 2.38$	27.58	$\mu_{C320} > \mu_{C520}$
ε_M	$\mu_{C35} < \mu_{C55}$	$t < -2.36$	-12.68	$\mu_{C35} < \mu_{C55}$
	$\mu_{C320} < \mu_{C520}$	$t < -2.38$	-6.04	$\mu_{C320} < \mu_{C520}$
σ_R	$\mu_{C35} < \mu_{C55}$	$t < -2.37$	-2.25	$\mu_{C35} = \mu_{C55}$
	$\mu_{C320} \neq \mu_{C520}$	$\|t\| > 2.69$	.301	$\mu_{C320} = \mu_{C520}$
E_T	$\mu_{C35} > \mu_{C55}$	$t > 2.36$	8.74	$\mu_{C35} > \mu_{C55}$
	$\mu_{C320} > \mu_{C520}$	$t > 2.38$	3.29	$\mu_{C320} > \mu_{C520}$
E_S	$\mu_{C35} > \mu_{C55}$	$t > 2.36$	17.10	$\mu_{C35} > \mu_{C55}$
	$\mu_{C320} > \mu_{C520}$	$t > 2.38$	8.31	$\mu_{C320} > \mu_{C520}$
σ_R/σ_M	$\mu_{C35} < \mu_{C55}$	$t < -2.37$	-18.25	$\mu_{C35} < \mu_{C55}$
	$\mu_{C320} < \mu_{C520}$	$t < -2.41$	-12.02	$\mu_{C320} < \mu_{C520}$
I_P	$\mu_{C35} \neq \mu_{C55}$	$\|t\| > 2.63$	-2.09	$\mu_{C35} = \mu_{C55}$
	$\mu_{C320} > \mu_{C520}$	$t > 2.38$	5.76	$\mu_{C320} > \mu_{C520}$
I_T	$\mu_{C35} > \mu_{C55}$	$t > 2.37$	6.72	$\mu_{C35} > \mu_{C55}$
	$\mu_{C320} > \mu_{C520}$	$t > 2.41$	9.87	$\mu_{C320} > \mu_{C520}$

Table 13 Cont.

Mechanical Property	Alternative Hypothesis	Critical Region	t	Conclusion (99% Confidence)
I_F	$\mu_{C35} \neq \mu_{C55}$	$\|t\| > 2.64$	-2.13	$\mu_{C35} = \mu_{C55}$
	$\mu_{C320} \neq \mu_{C520}$	$\|t\| > 2.69$	0.34	$\mu_{C320} = \mu_{C520}$
I_C	$\mu_{C35} > \mu_{C55}$	$t > 2.37$	19.12	$\mu_{C35} > \mu_{C55}$
	$\mu_{C320} > \mu_{C520}$	$t > 2.41$	21.34	$\mu_{C320} > \mu_{C520}$
I_C/I_F	$\mu_{C35} > \mu_{C55}$	$t > 2.37$	12.93	$\mu_{C35} > \mu_{C55}$
	$\mu_{C320} > \mu_{C520}$	$t > 2.41$	8.66	$\mu_{C320} > \mu_{C520}$

t-statistic. Use of the approximate t-statistic to test the null hypothesis does not change any of the conclusions in Tables 12 and 13.

Based primarily on our judgment and guided by the t-tests, the effects of temperature and strain-rate on the primary mechanical properties are summarized in Tables 14-18. The four test conditions are shown in matrix form with the two levels of constant strain rate horizontal and the two levels of constant temperature vertical. At each matrix location, the mean, standard deviation, and sample size are recorded. Test conditions connected by a dashed line indicate no change in the mechanical property between those two conditions. Test conditions connected by a solid arrow indicate an increase in the mechanical property in the direction of the arrow.

As expected, the maximum stress increases with decreasing temperature and increasing strain rate. The total dissipated energy follows the same trends for temperature and strain rate. The initial tangent modulus increases with increasing strain rate but is independent of temperature. The most interesting result is that the residual stress shows no change with strain rate, which suggests that the stress-strain curve is rate independent at large strains. However, the residual stress does increase with decreasing temperature.

The results for strain at maximum stress show that at both temperatures, ε_M increases with decreasing strain rate. However, Table 15 does not indicate how ε_M varies with temperature since the t-tests show that ε_M increases with increasing temperature at 10^{-5}/sec and increases with decreasing temperature at 10^{-3}/sec. This case indicates a possible coupling between the effects of temperature and strain rate which would render the pairwise t-tests inappropriate. In this case, an analysis of variance would be more suitable.

LINEAR REGRESSION MODELS BASED ON TOTAL DISSIPATED ENERGY

Correlations between any two mechanical properties can be investigated by creating ordered pairs of the two properties for each test and plotting the resulting points in the plane. Rather than producing plots for each test condition, plots are produced for each of the two levels of constant temperature to illustrate the effect of strain rate.

The most important mechanical property in terms of ice load calculations is the maximum stress. We seek correlations for this quantity by

Table 14

SUMMARY OF MEAN VALUES FOR σ_M (PSI)

$\dot{\epsilon}$ \ T	-5°C	-20°C
10^{-5}/sec	316±122 67	393±103 37
10^{-3}/sec	69 879±234	41 1410±202

Table 15

SUMMARY OF MEAN VALUE FOR ε_M (%)

$\dot{\epsilon}$ \ T	-5°C	-20°C
10^{-5}/sec	.400±.161 67	.322±.100 37
10^{-3}/sec	69 .143±.050	41 .209±.064

Table 16

SUMMARY OF MEAN VALUE FOR σ_R (PSI)

T / $\dot{\epsilon}$	-5°C	-20°C
10^{-5}/sec	200±44 61	249±72 29
10^{-3}/sec	42 177±57	18 255±76

Table 17

SUMMARY OF MEAN VALUE FOR E_T (PSI × 10^6)

T / $\dot{\epsilon}$	-5°C	-20°C
10^{-5}/sec	.509±.356 67	.690±.576 37
10^{-3}/sec	69 1.010±.312	41 1.135±.614

Table 18

SUMMARY OF MEAN VALUE FOR I_T (in-lbf)/in^3

$\dot{\epsilon}$ \ T	-5°C	-20°C
10^{-5}/sec	10.19±2.50 61	12.70±3.21 29
10^{-3}/sec	42 13.74±2.82	18 22.35±3.35

Table 19

LINEAR REGRESSION MODELS BASED ON TOTAL DISSIPATED ENERGY

Independent Variable	Dependent Variable	Test Condition	Linear Coefficient	Intercept	R^2
I_T	σ_M	C55	37.31	-62.58	.54
I_T	σ_M	C520	22.11	120.71	.47
I_T	σ_M	C35	30.70	433.61	.36
I_T	σ_M	C320	31.54	699.45	.48
I_T	σ_R	C55	16.57	31.08	.88
I_T	σ_R	C520	21.61	-25.63	.93
I_T	σ_R	C35	17.24	-59.46	.72
I_T	σ_R	C320	18.20	-151.22	.64

plotting the maximum stress as a function of the other primary mechanical properties (i.e., ε_M, σ_R, E_T, and I_T) in Figures 1-8. Figures 1 and 2 are of interest since they contain the loci of points for the peak value of the stress-strain curve and illustrate the large variation in the mechanical response within a particular test condition and between test conditions. Linear regression lines were calculated for each property pair at each test condition in Figures 1-8. The property pair which showed the strongest correlation (i.e., the highest R^2 value) is σ_M vs I_T. The regression lines are drawn for this pair in Figures 7 and 8 and the regression parameters are listed in Table 19. Regression models for the other property pairs had significantly lower R^2 values and for this reason they are not drawn or tabulated here.

Plots and linear regression models were also produced for all pairwise combinations of the remaining primary mechanical properties. The only property pair which showed a correlation is σ_R vs I_T. Plots for this pair together with the regression line for each test condition are shown in Figures 9 and 10. The regression parameters for this pair at each test condition are listed in Table 19.

The positive correlations for σ_M and σ_R with I_T are not surprising when one considers the general shape of the stress-strain curve for multi-year ridge ice. The interesting observation is the similarity in slopes (except possibly for σ_M vs I_T at C520) at each test condition for the two models. This suggests that the variations of σ_M with I_T and σ_R with I_T are independent of temperature and strain rate. The temperature and strain rate effects on the σ_M vs I_T and σ_R vs I_T models are accounted for by translations of the regression lines in the plane.

LINEAR REGRESSION MODELS BASED ON ENERGY DISSIPATED AT PEAK STRENGTH

Our ability to calculate ice loads would be greatly improved if a failure criteria could be formulated to predict the maximum stress. Failure or yield criteria are often formulated by appealing to energy considerations. We have already seen some correlation between the maximum stress (σ_M) and the total dissipated energy (I_T) in Figures 7 and 8. However, I_T depends on the post peak behavior of the stress-strain curve and, consequently, would not be useful in the prediction of σ_M. Instead, an energy-based failure criterion

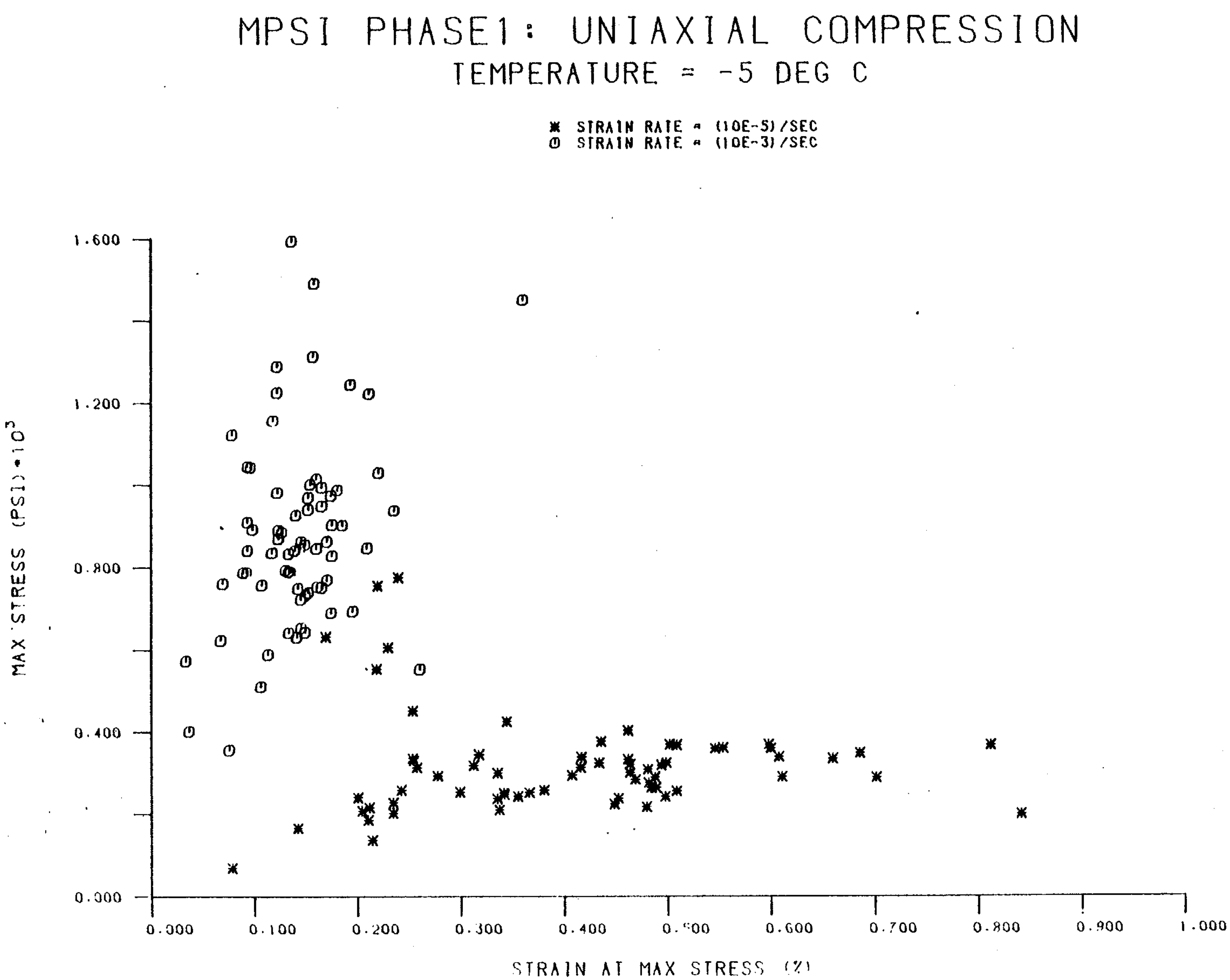

Fig. 1 - Maximum stress as a function of strain at maximum stress for T = -5°C.

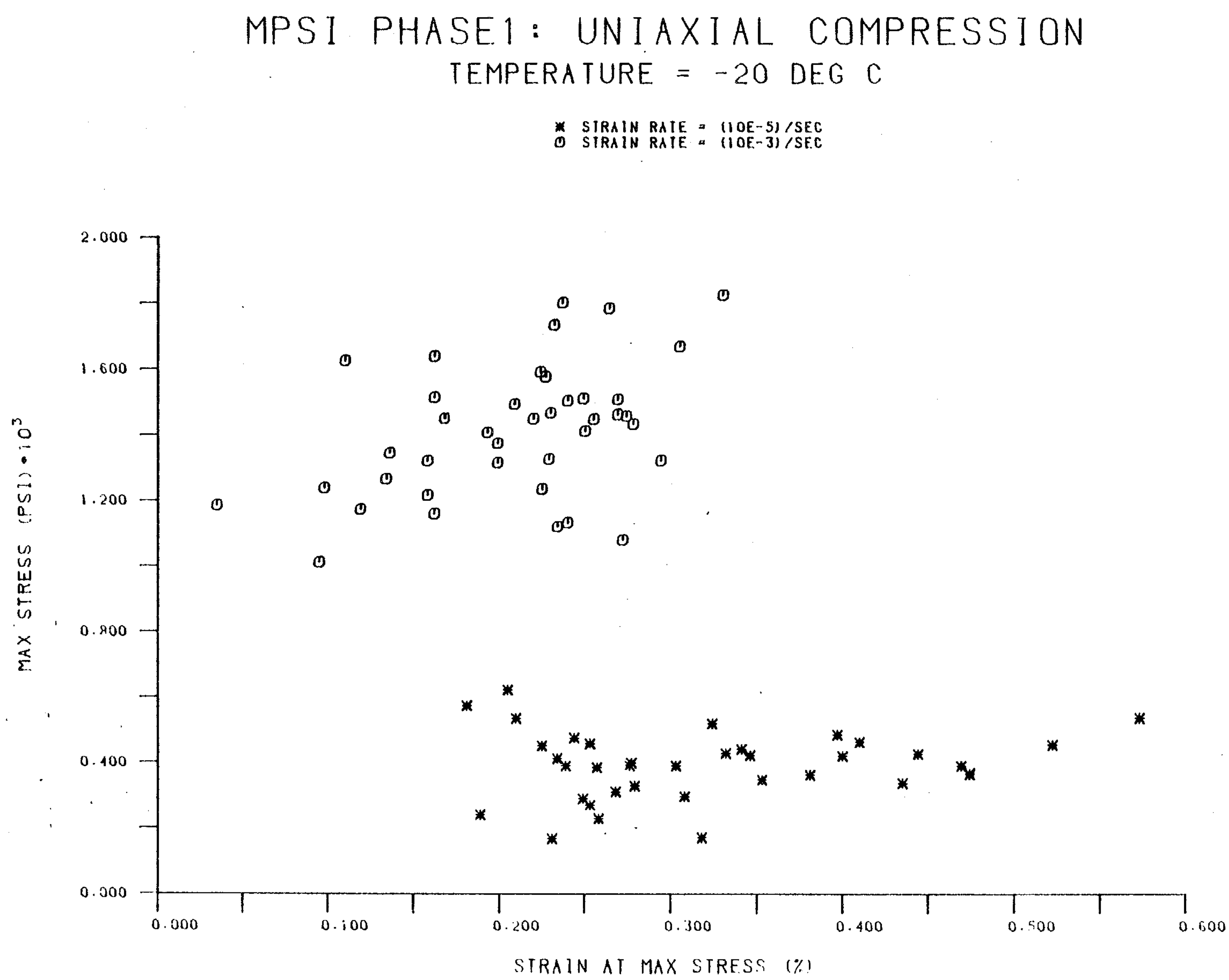

Fig. 2 - Maximum stress as a function of strain at maximum stress for T = -20°C.

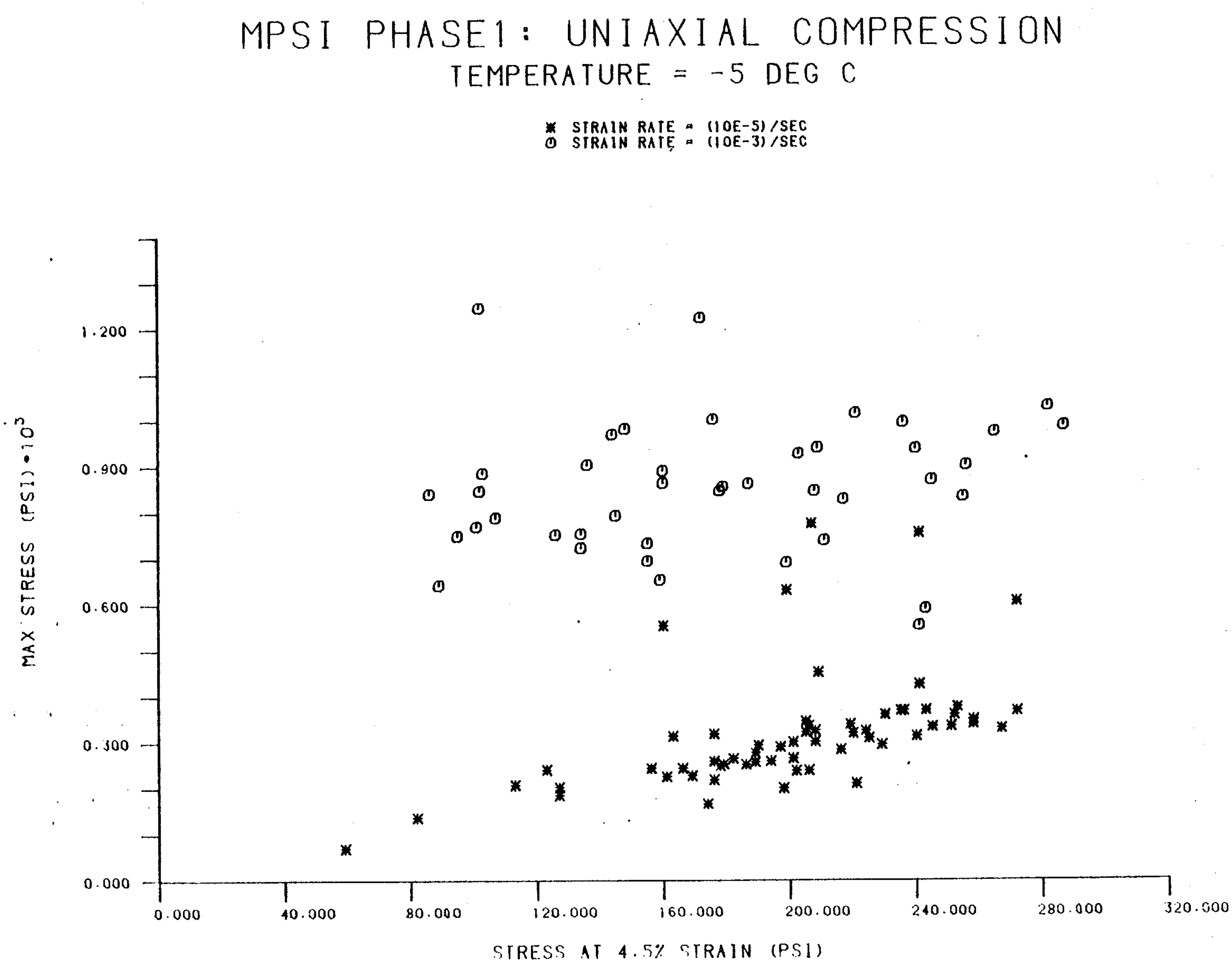

Fig. 3 - Maximum stress as a function of stress at 4.5% strain for T = -5°C.

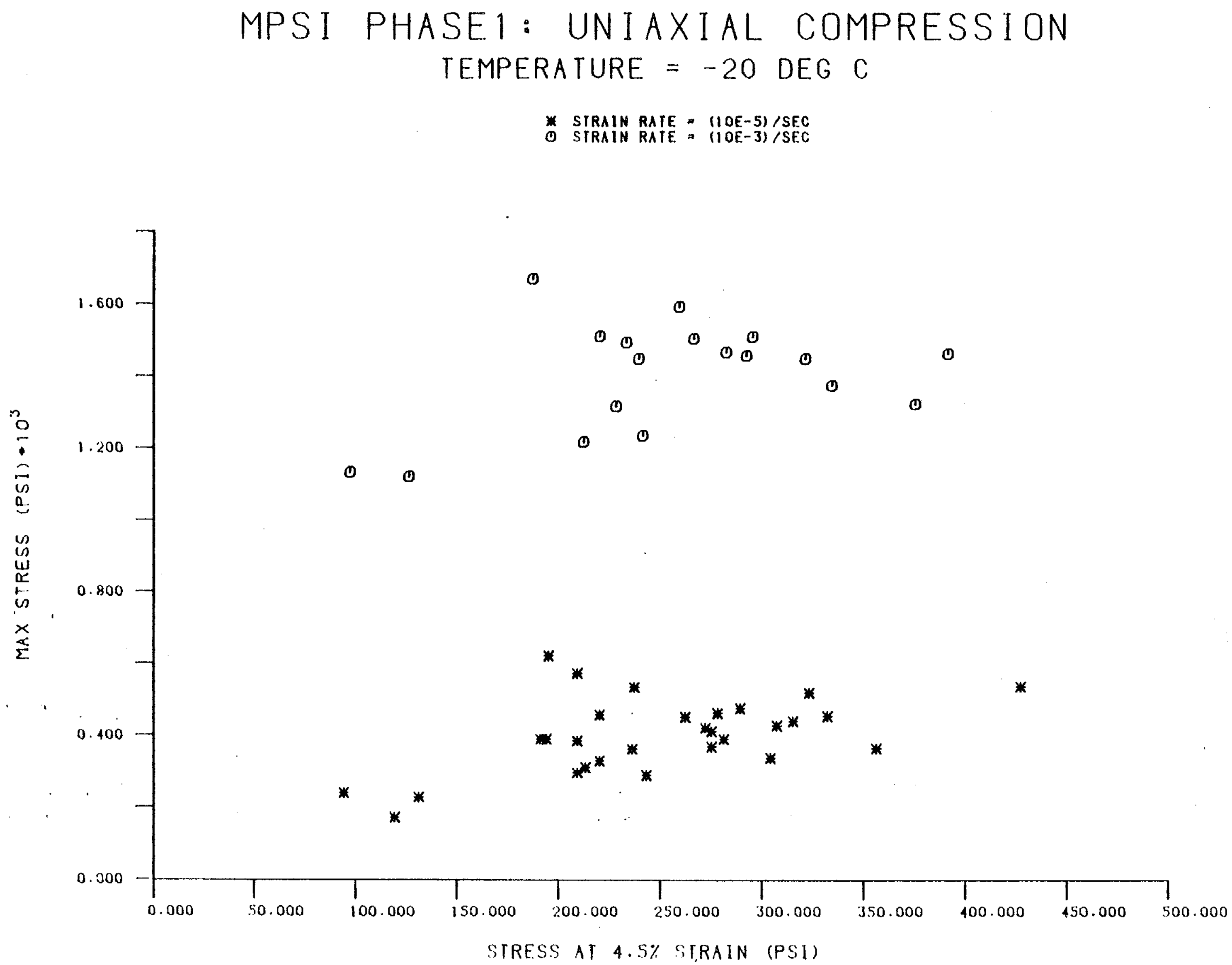

Fig. 4 - Maximum stress as a function of stress at 4.5% strain for T = -20°C.

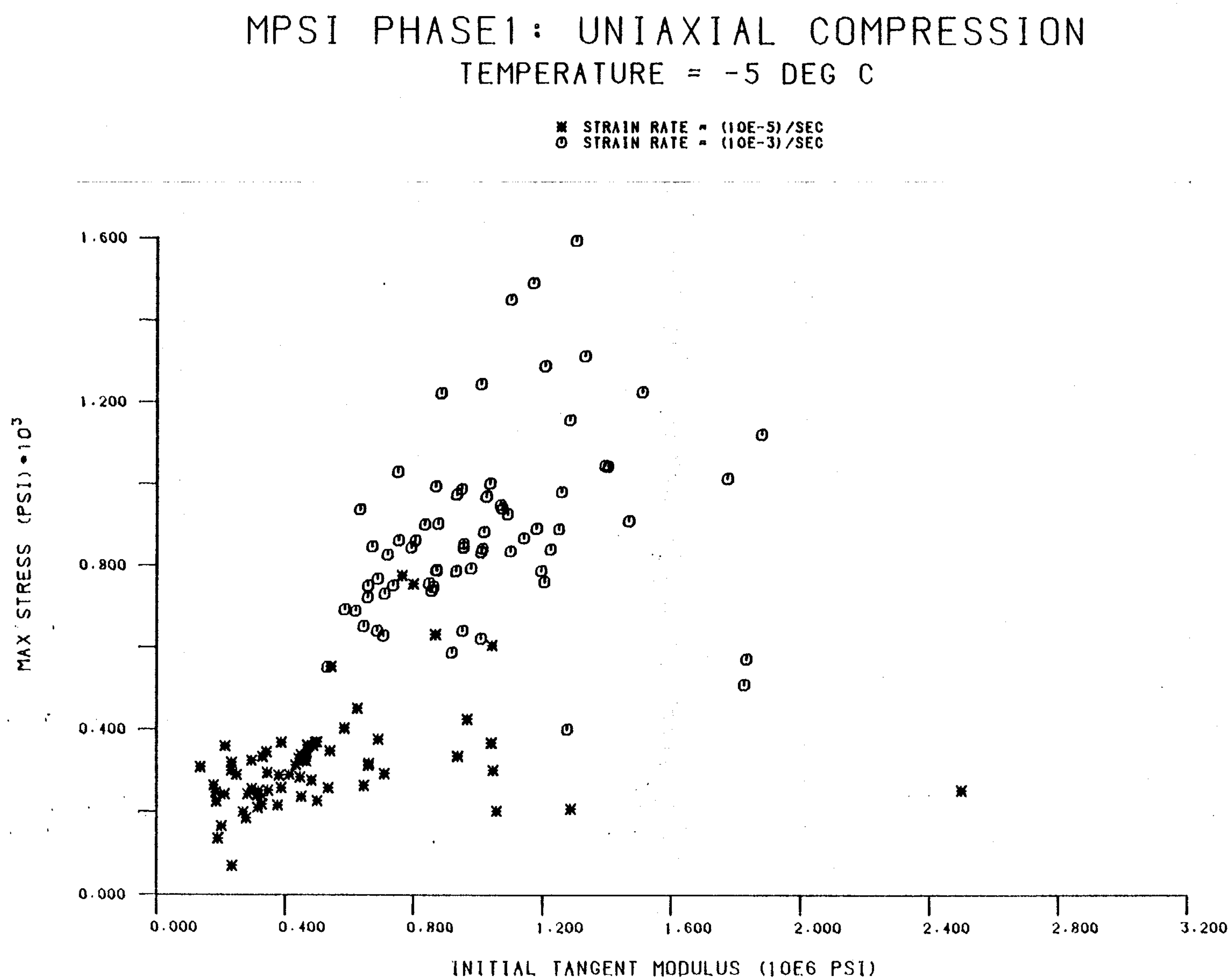

Fig. 5 - Maximum stress as a function of the initial tangent modulus for T = -5°C.

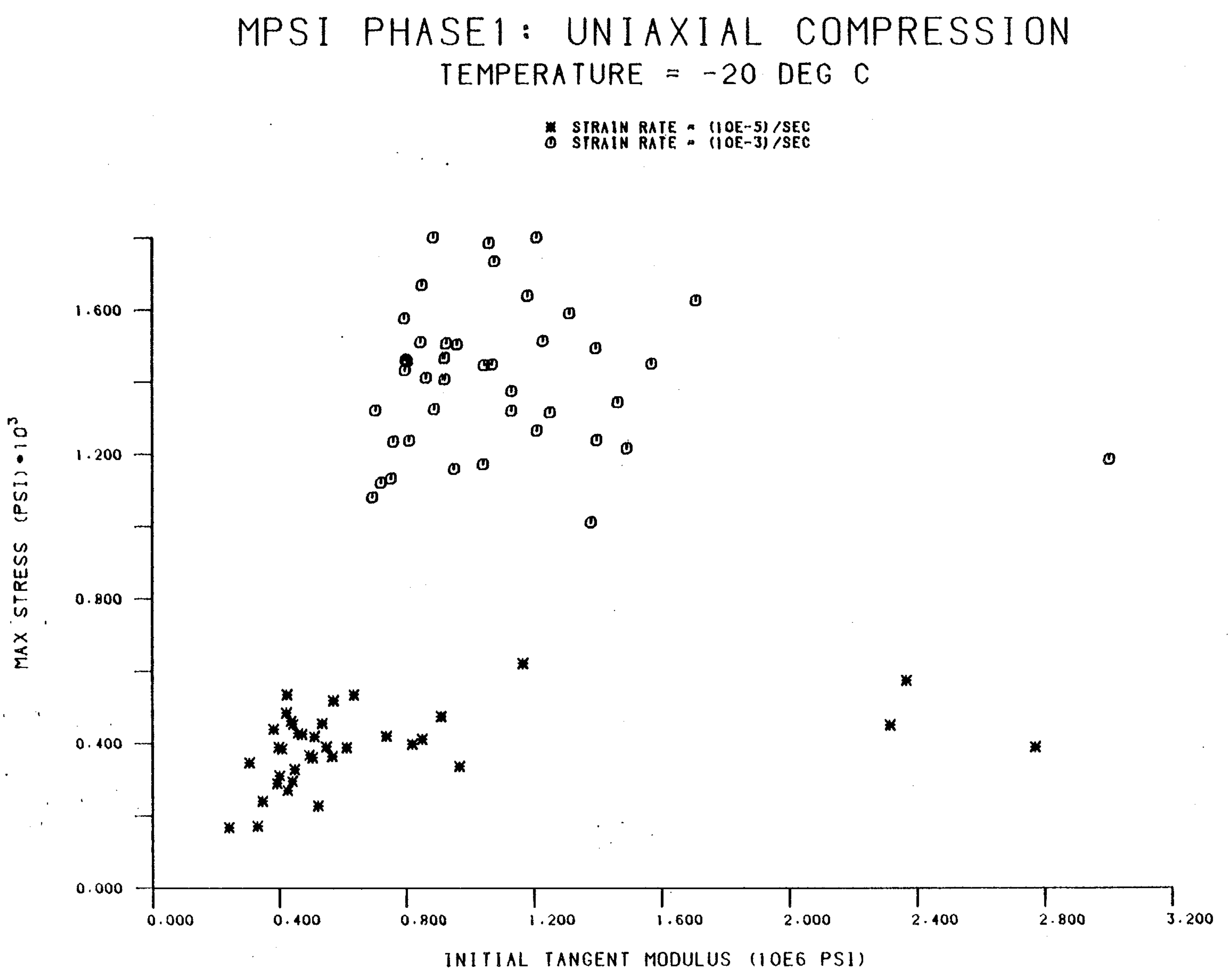

Fig. 6 - Maximum stress as a function of the initial tangent modulus for T = -20°C.

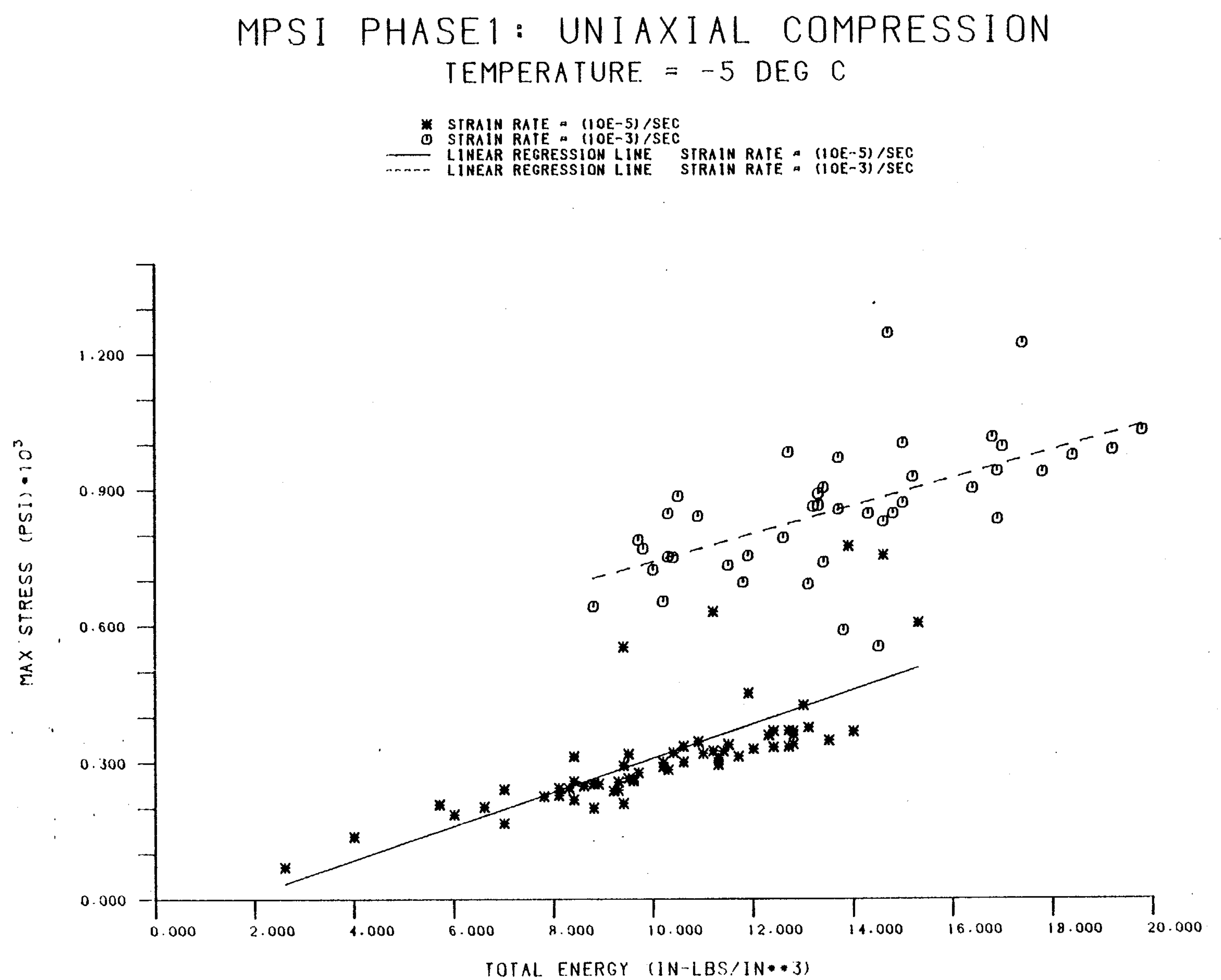

Fig. 7 - Maximum stress as a function of the total energy for T = -5°C.

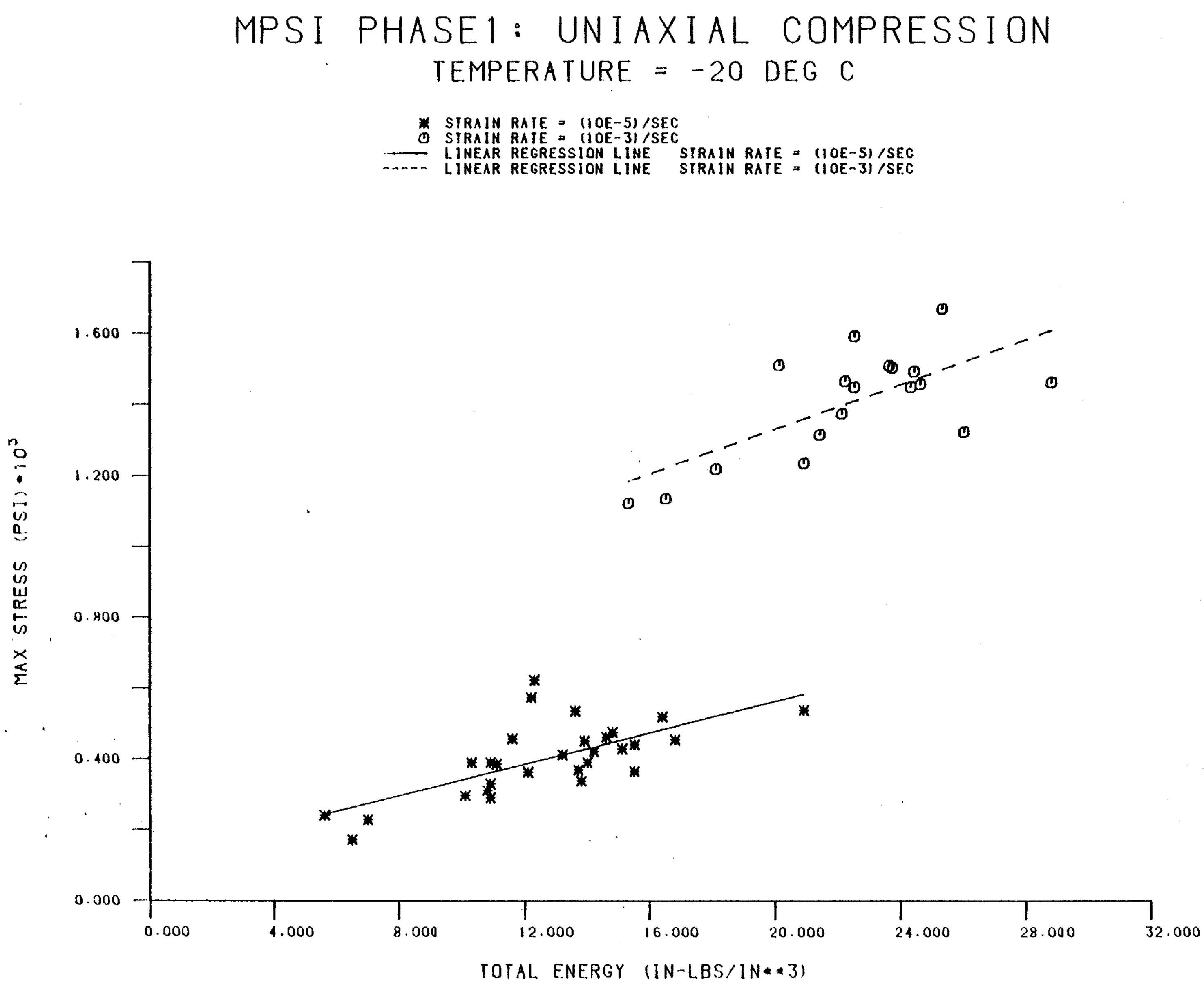

Fig. 8 - Maximum stress as a function of the total energy for T = -20°C.

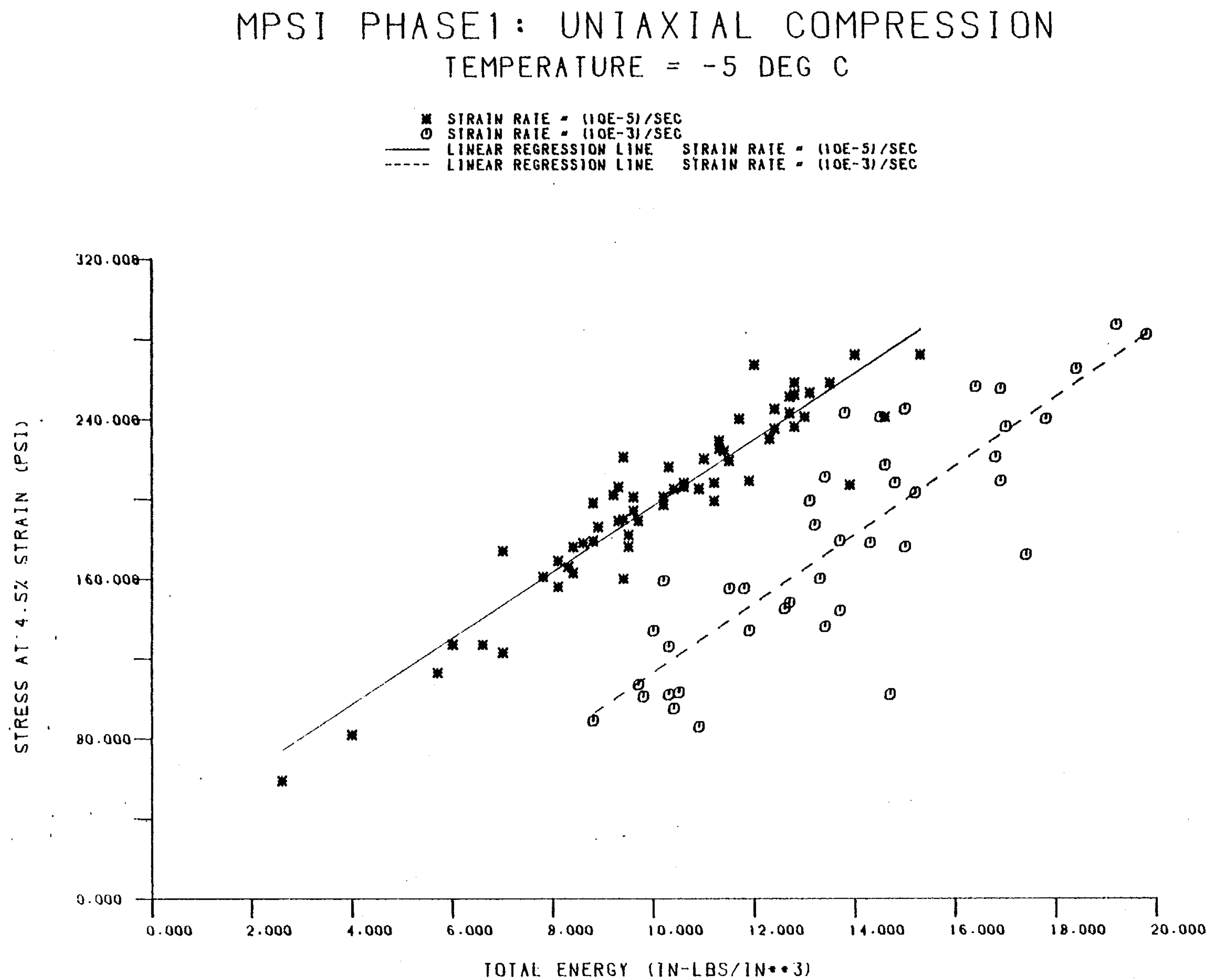

Fig. 9 - Stress at 4.5% strain as a function of the total energy for T = -5°C.

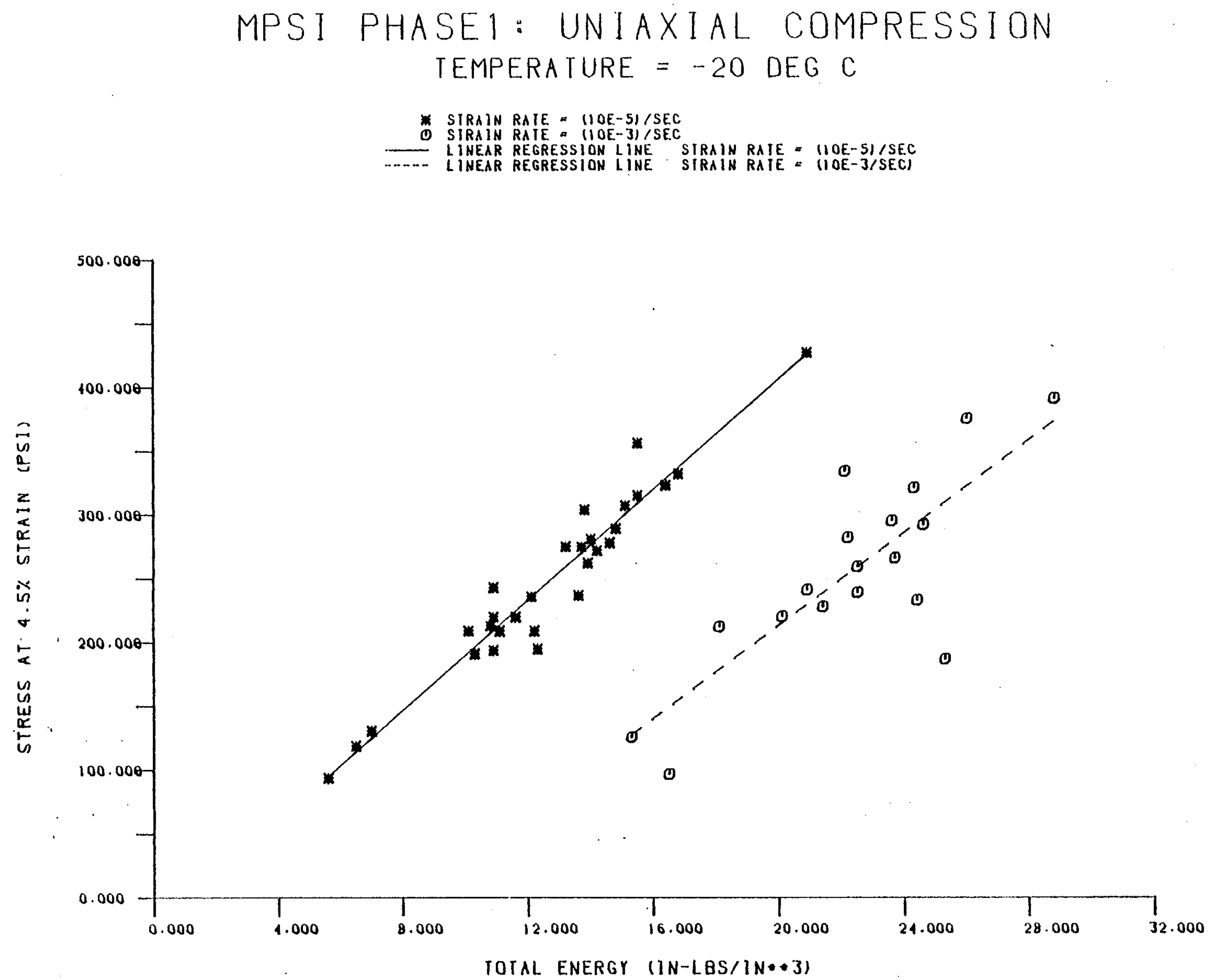

Fig. 10 - Stress at 4.5% strain as a function of the total energy for T = -20°C.

for σ_M should be formulated in terms of energy dissipated up to peak strength (I_P). We investigate this possibility by plotting σ_M vs I_P in Figures 11 and 12. Regression lines are calculated for this property pair, and the regression parameters are listed in Table 20.

Comparison of the R^2 values in Table 20 shows a stronger correlation for the high strain rate test conditions (i.e., C35 and C320). The weaker correlations for the low strain rate test condition are probably a result of the flatness of the low strain rate stress-strain curve. There, the maximum stress is difficult to determine causing greater error in the calculation of I_P. Comparison of the R^2 values for σ_M in Table 20 with those in Table 19 shows a stronger correlation for the model based on I_T. In contrast to the σ_M vs I_T models, the σ_M vs I_P models show no similarity in slopes.

Failure and yield criteria have traditionally been formulated in stress space. However, some recent work in the theory of plasticity has suggested that a more natural formulation for failure criteria would be in strain space. This would be particularly true for a material such as ice which exhibits a strain-softening behavior. A stress formulation for the failure criterion of a strain-softening material would have to be double valued whereas a strain formulation would remain single-valued. Thus we seek correlations between the failure strain (i.e., strain at maximum stress), ε_M, and the energy dissipated at maximum stress. The ε_M vs I_P ordered pairs for each test condition are plotted in Figures 13 and 14. Regression lines are calculated for each test condition, and the parameters are listed in Table 20. The high R^2 values in Table 20 are to be expected since,

$$I_P = \int_0^{\varepsilon_M} \sigma(\varepsilon)d\varepsilon = f(\varepsilon_M) \text{ .}$$

However, we note the similarities in slopes for the two pairs of test conditions with constant strain rate. Regression lines are recalculated by combining all data points for the two levels of constant strain rate. The combined regression lines along with the data points are shown in Figures 15 and 16, and the regression parameters are listed in Table 20. The high R^2 values for the combined data points indicate that a temperature independent model for ε_M vs I_P is plausible. Again we note a stronger correlation for the high strain rate than the low strain rate.

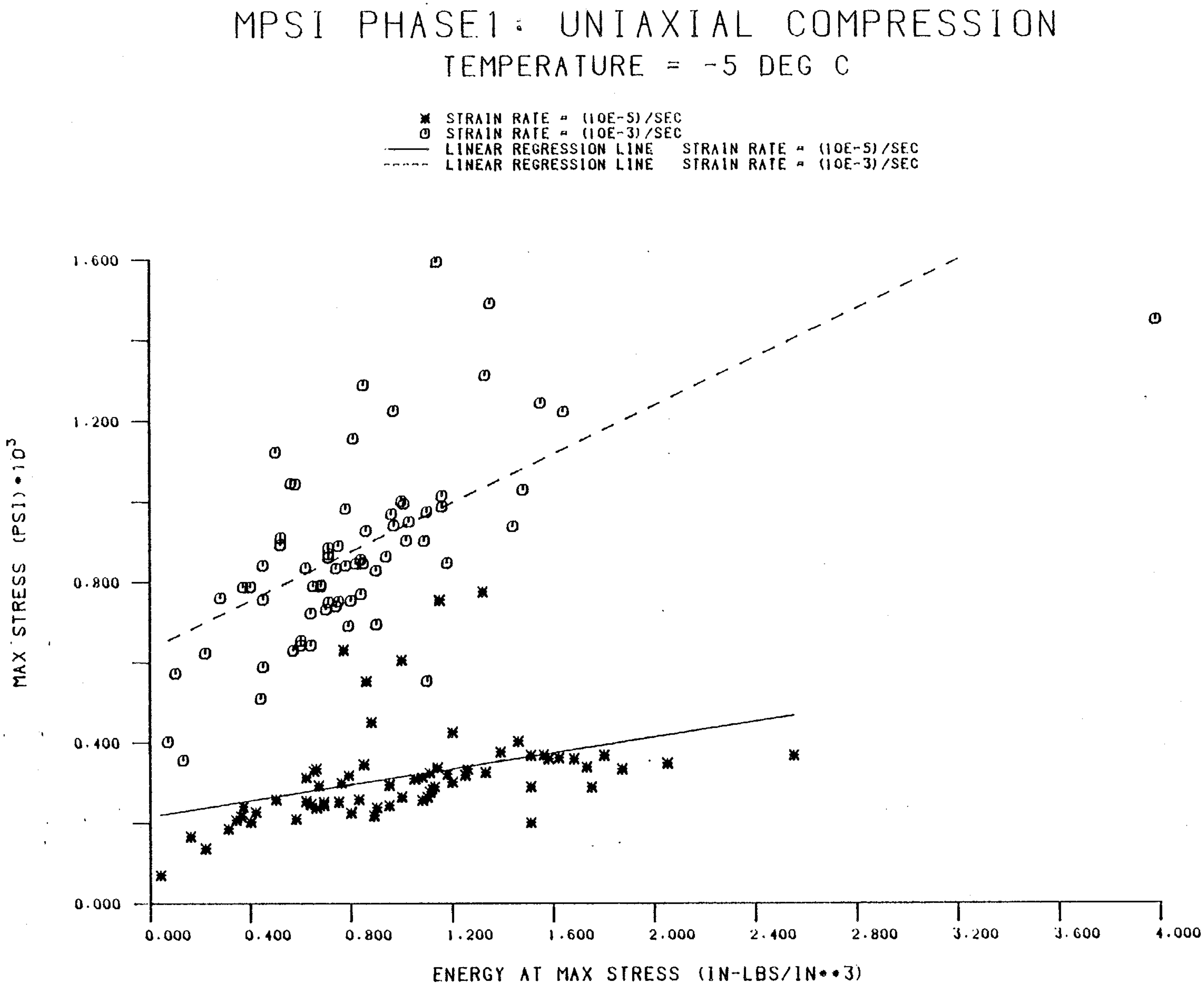

Fig. 11 - Maximum stress as a function of the energy dissipated at maximum stress for T = -5°C.

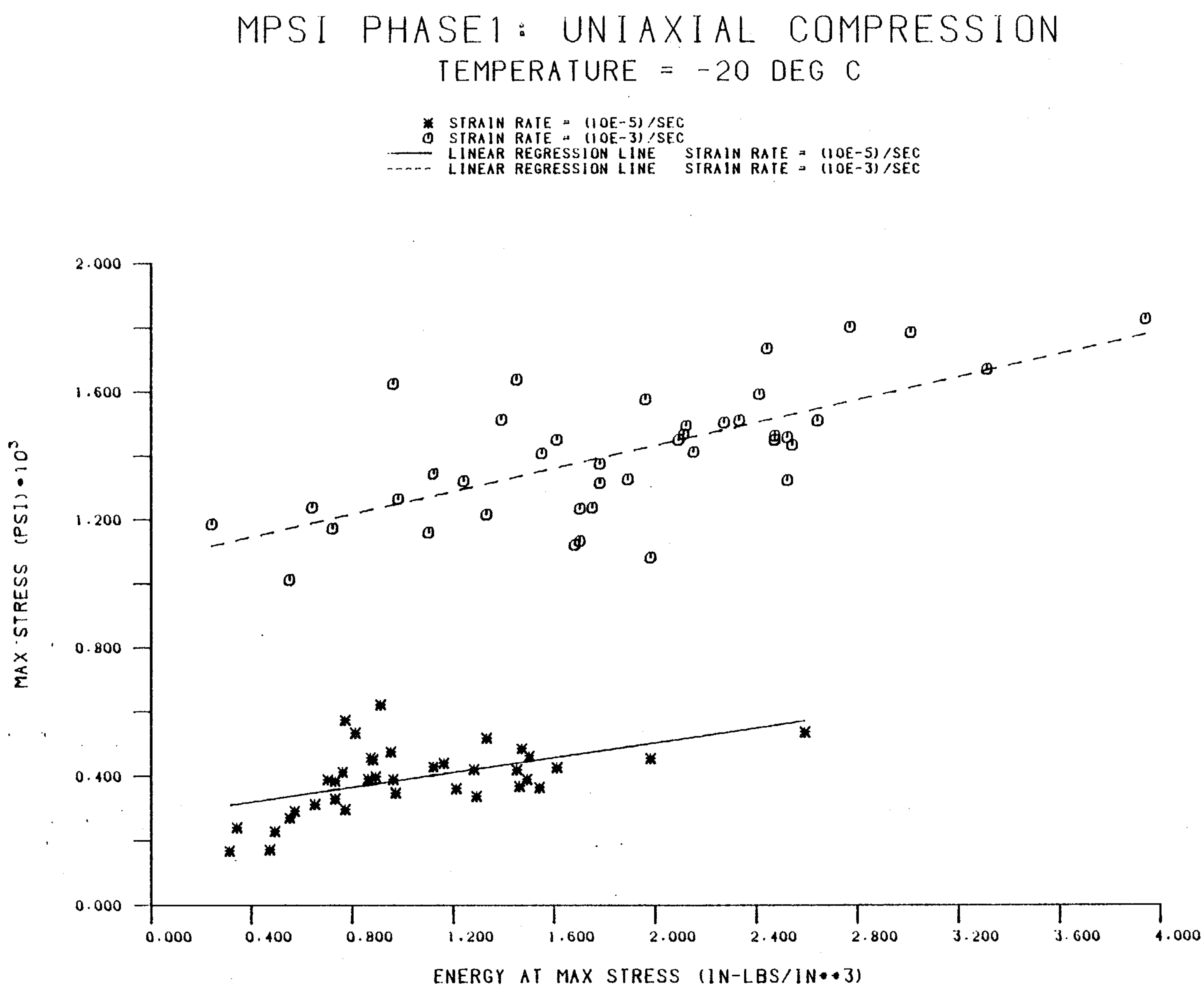

Fig. 12 - Maximum stress as a function of the energy dissipated at maximum stress for T = -20°C.

Table 20

LINEAR REGRESSION MODELS BASED ON ENERGY DISSIPATED AT MAXIMUM STRESS

Independent Variable	Dependent Variable	Test Condition	Linear Coefficient	Intercept	R^2
I_P	σ_M	C55	98.05	216.68	.15
I_P	σ_M	C520	114.25	274.68	.28
I_P	σ_M	C35	292.70	635.26	.40
I_P	σ_M	C320	178.16	1075.01	.46
I_P	ε_M	C55	0.285	0.112	.75
I_P	ε_M	C520	0.187	0.128	.79
I_P	ε_M	C35	0.086	0.071	.76
I_P	ε_M	C320	0.077	0.063	.87
I_P	ε_M	C55, C520	0.250	0.117	.67
I_P	ε_M	C35, C320	0.074	0.077	.85

Table 21

SUMMARY OF MEAN VALUES FOR I_P (in-lbf)/in^3

$\dot{\epsilon}$ \ T	-5°C	-20°C
10^{-5}/sec	1.014±.488 67	1.038±.473 37
10^{-3}/sec	69 .836±.507	41 1.883±.770

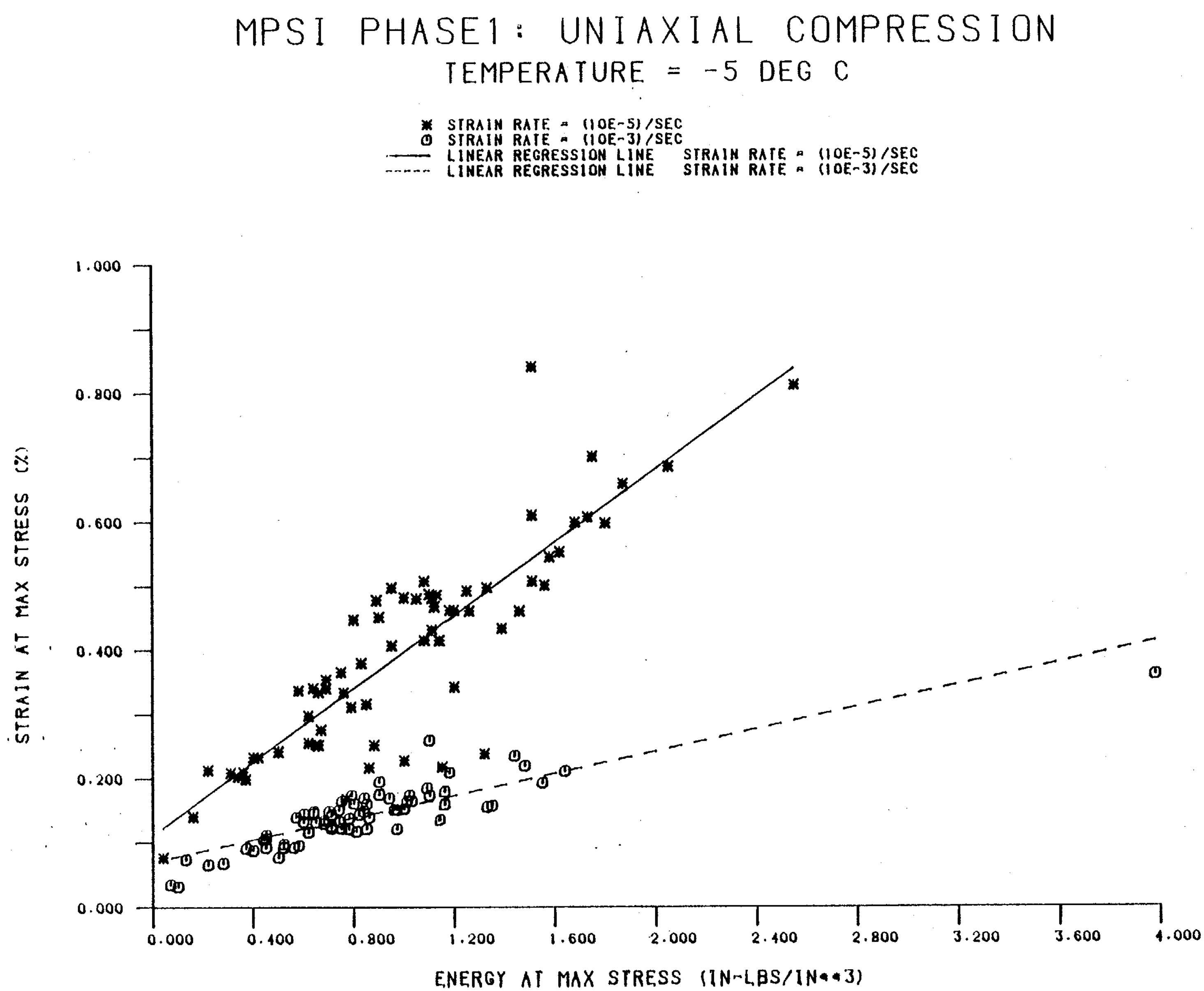

Fig. 13 - Strain at maximum stress as a function of the energy dissipated at maximum stress for T = -5°C.

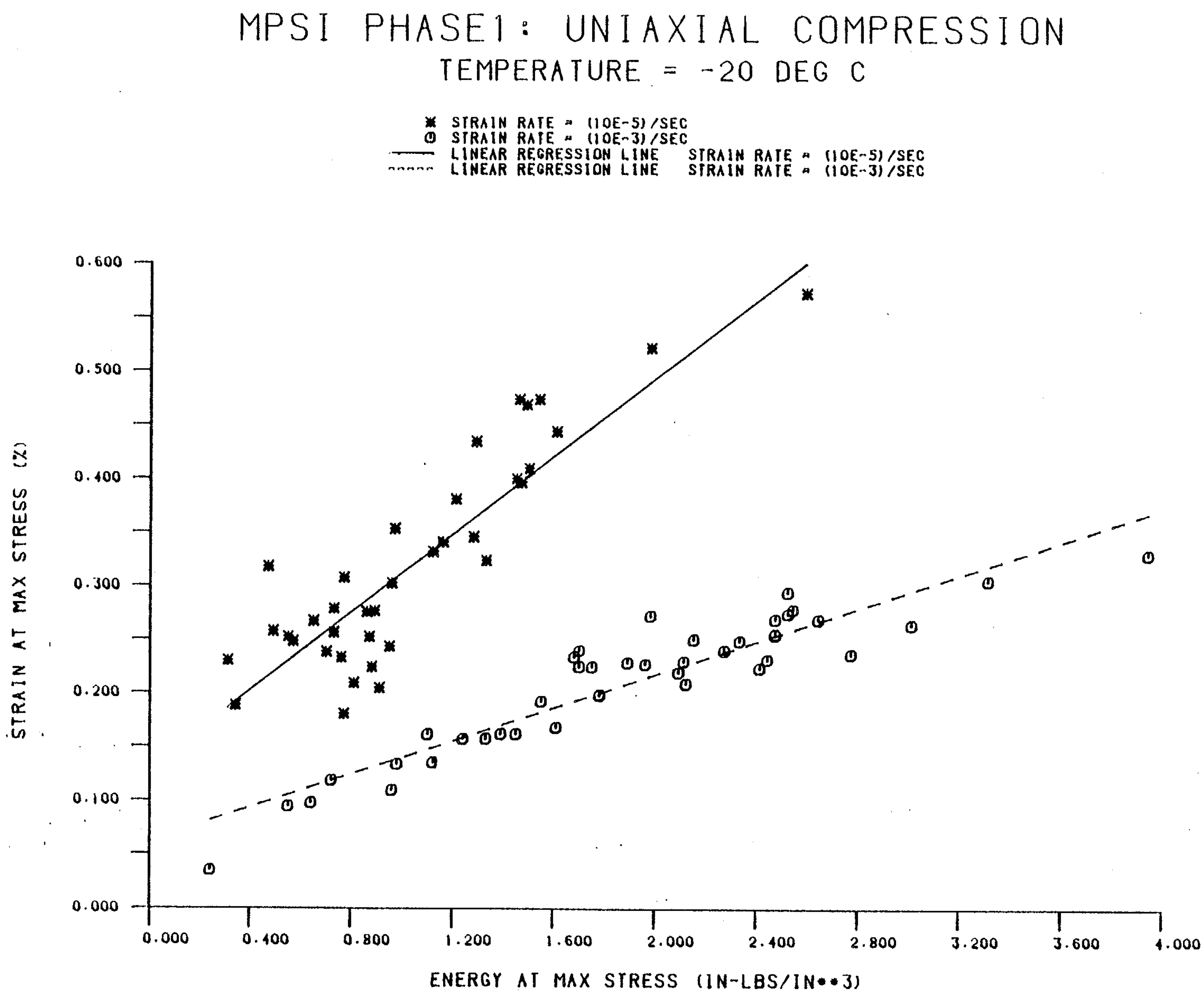

Fig. 14 - Strain at maximum stress as a function of the energy dissipated at maximum stress for T = -20°C.

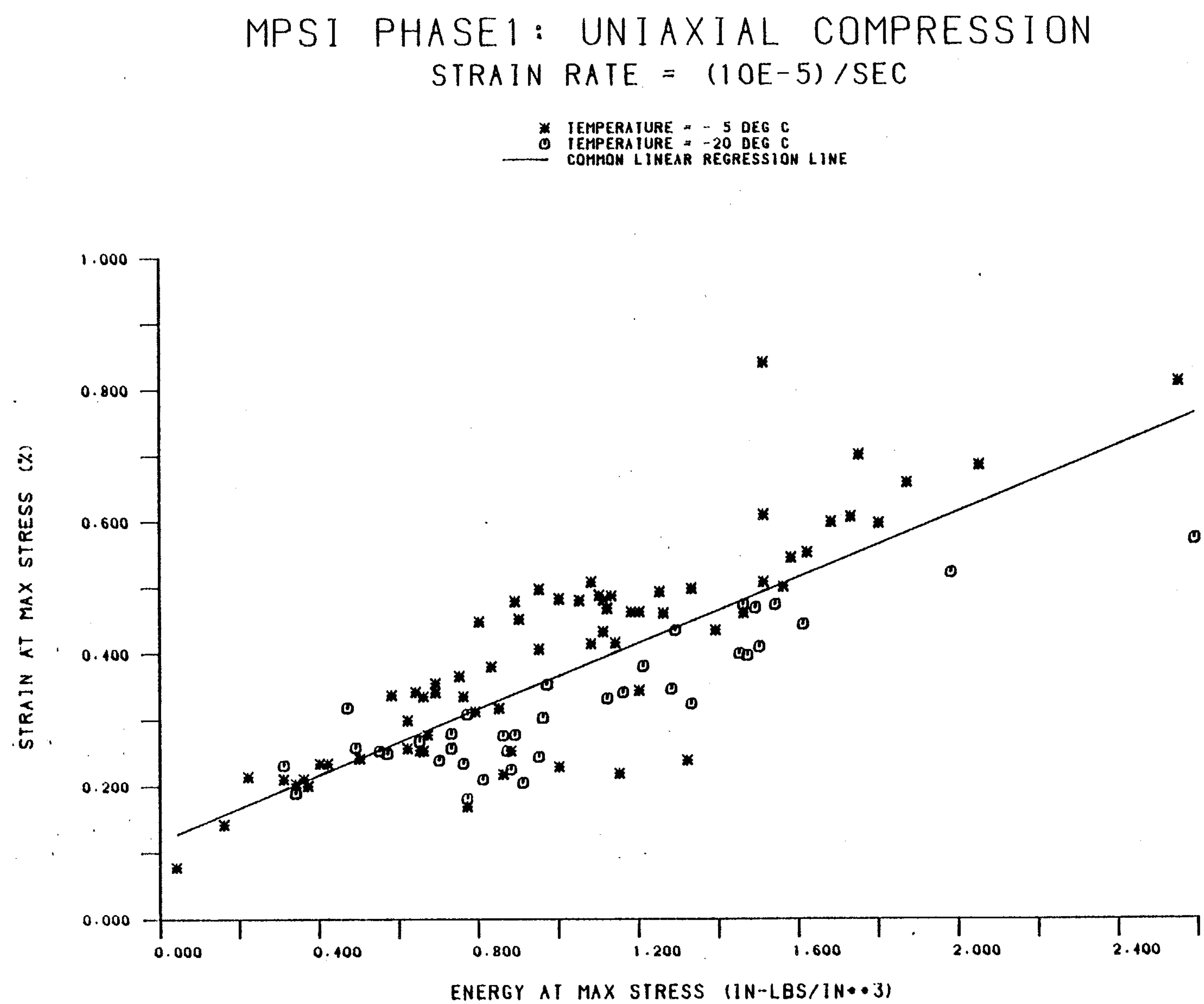

Fig. 15 - Strain at maximum stress as a function of the energy dissipated at maximum stress for $\dot{\varepsilon} = 10^{-5}$/sec.

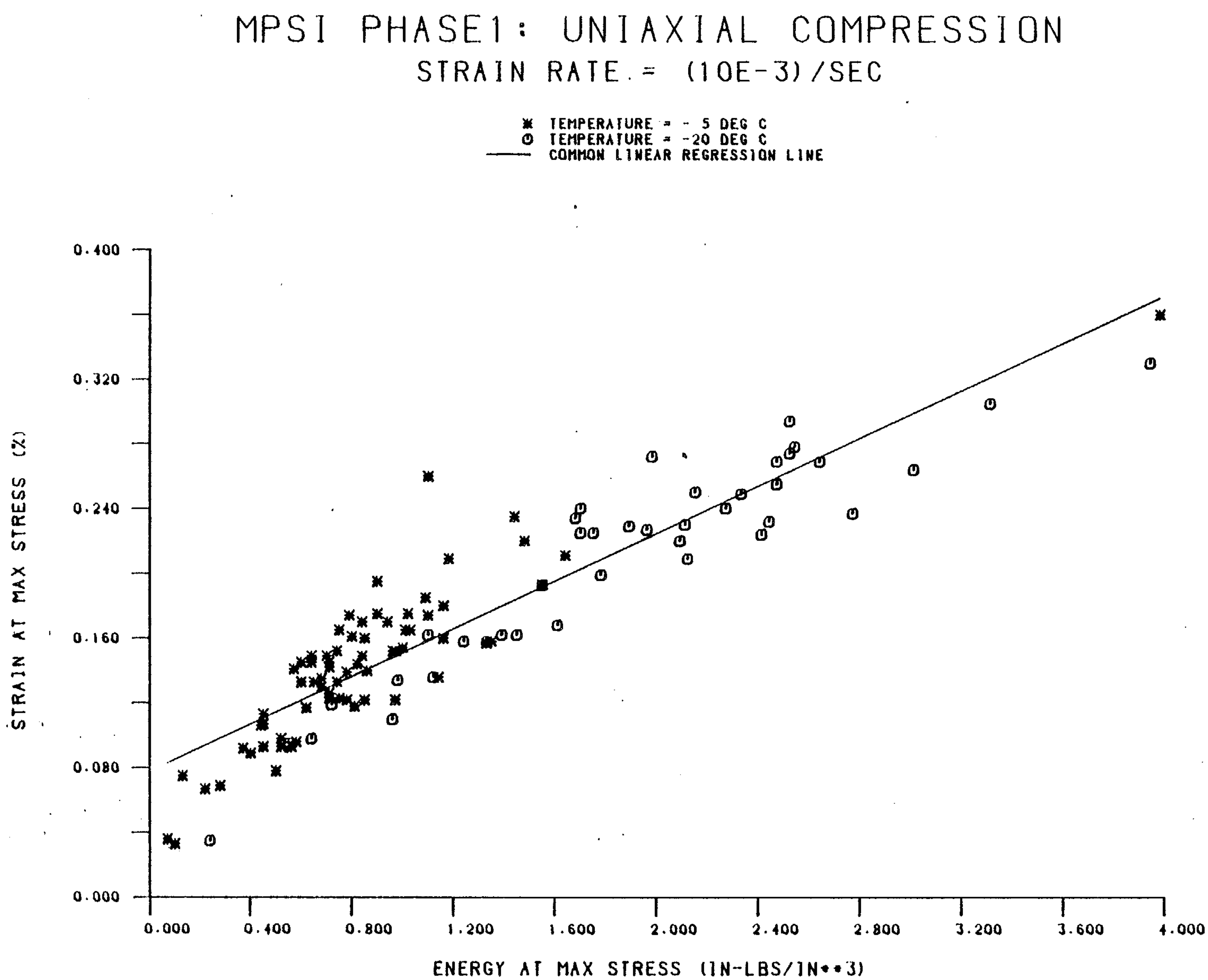

Fig. 16 - Strain at maximum stress as a function of the energy dissipated at maximum stress for $\dot{\varepsilon} = 10^{-3}$/sec.

The effects of temperature and strain rate on I_p are again investigated by conducting t-tests for the two levels of constant temperature and strain rate. The results are summarized in Table 21. This summary shows that at all four test conditions except for C320, the mean values of I_p are similar. If the mean value for C320 was similar to the other mean values, then we could hypothesize that the peak value for the stress-strain curve is associated with a critical value of energy independent of temperature and strain rate. This is a very attractive hypothesis and should not be abandoned without a closer examination of why the mean value of C320 is different from the others. One possibility for the difference is due to the fact that all tests are included in each sample population of a given test condition when calculating I_p. Selective editing of the tests according to ice type or failure mode could significantly change the mean values in Table 21 and hence change the conclusions of the pairwise t-tests. If editing of the data set proves fruitless, then a failure criteria based on I_p over a more restrictive temperature, strain rate regime should be investigated.

IDEALIZED STRESS-STRAIN RESPONSE

When discussing the mechanical response of a material, all mechanical properties should be taken into account before a general impression of the material's behavior can be made. The stress-strain curve for multi-year ridge ice is a nonmonotonic curve which has a peak stress at approximately .1-.4% strain and decreases to a fairly constant value at strains greater than 4% (see Mellor[8] for a detailed account of the stress-strain behavior of ice). This type of curve can be characterized by the initial tangent modulus, the peak value of stress and the constant stress at large strains. We will attempt to define a single parameter which depends on these properties. This parameter would then provide a useful basis for comparing different stress-strain curves and discussing changes in the mechanical response with temperature and strain rate.

Engineers commonly characterize the mechanical response of materials in qualitative terms as being either brittle or ductile. This terminology is useful here, but the usual definitions of these terms must be modified before being applied to multi-year ridge ice. A ductile material is usually defined as a material that undergoes appreciable deformation before rupture (failure), whereas a brittle material undergoes very little deformation prior to rupture.

These definitions are not very suitable for ice since an ice sample tested at supposedly brittle conditions (e.g., 10^{-3}/sec strain rate) can still support loads at large strains.

More suitable definitions arise by considering the idealized response of a ductile and brittle material. A truly ductile material is often modeled as a perfectly plastic material whose characteristic stress-strain shape is a rectangle elongated along the strain axis. This model allows the material to flow indefinitely under a constant yield stress. A truly brittle material is often modeled as a linear elastic material whose stress-strain shape is a sharp ramp. This model allows the material to attain high stresses very rapidly and unloads instantaneously when the failure stress is reached. These two models, illustrated in Figure 17, are consistent with the usual definitions of ductile and brittle since plastic strains are usually quite large when compared to elastic strains. However, it is the shape of these models that should be kept in mind when classifying the response of multi-year ridge ice. A flat stress-strain curve with a fairly constant post-peak behavior is defined as a ductile response, and a sharp stress-strain curve with rapid unloading after the peak stress is defined as a brittle response. The notions of "flat" and "sharp" stress-strain curves will be quantified in the following sections.

ENERGY COMPONENTS

Perhaps the most appropriate mechanical property to describe mechanical response is the total dissipated energy since its calculation takes into account all aspects of the stress-strain curve. However, this quantity is not very useful in describing the shape of the stress-strain curve since no information is provided about its distribution in the stress-strain plane. The observation in a previous section that the residual stress appears to be rate independent suggests a useful decomposition of the total energy which would permit a quantitative measure of the shape of the stress-strain curve. If the residual stress is indeed independent of strain rate, then its contribution to the calculation of the total energy would also be rate independent. We define this rate independent contribution as the flow energy. This quantity is estimated by calculating the area of the trapezoid bound by the initial tangent modulus, the constant residual stress, the constant strain of 0.045, and the strain axis. Thus, the flow energy is given by the equation,

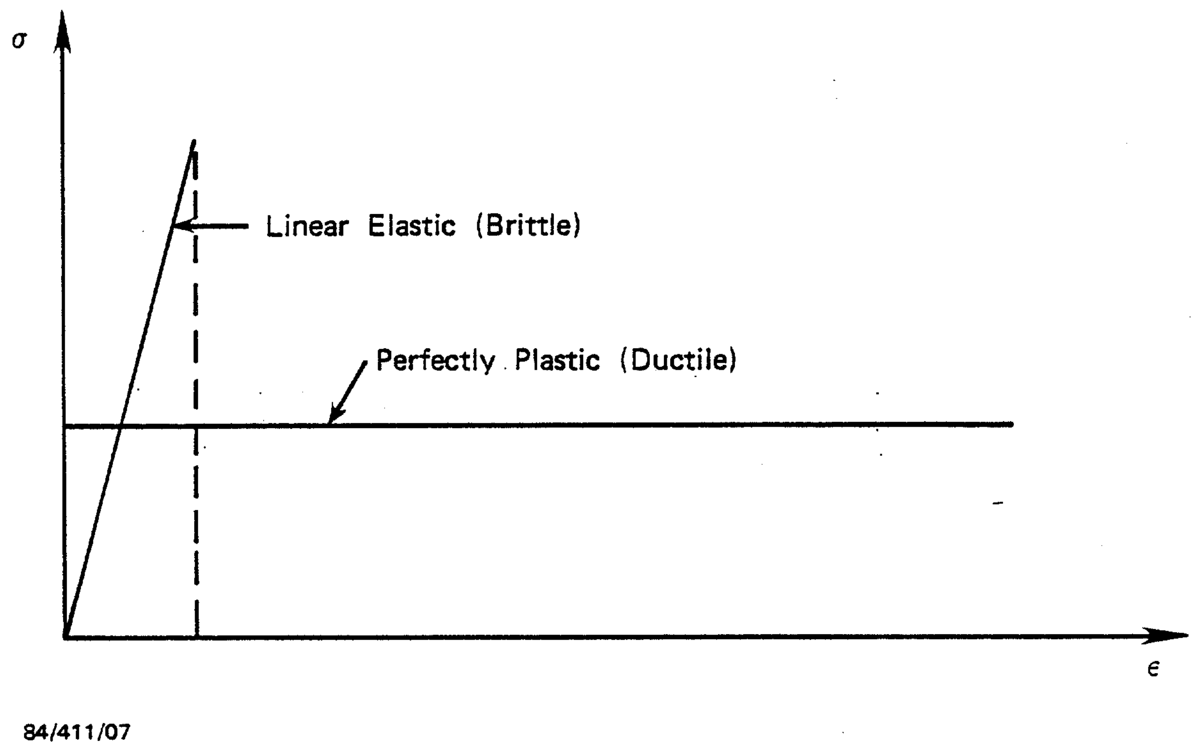

Fig. 17 - Schematic diagram of idealized material models.

$$I_F = \frac{1}{2}\left(0.09 - \frac{\sigma_R}{E_T}\right)\sigma_R \quad .$$

The difference between the total energy (I_T) and the flow energy (I_F) would be the rate dependent contribution and is defined as the crushing energy (I_C). In some cases, it is possible that our estimation of the flow energy is greater than the total energy which would result in a negative crushing energy. In this event, the flow energy is set equal to the total energy, and the crushing energy is set equal to zero. Figure 18 is a schematic representation of the decomposition of the total energy. Similar to the summaries for the primary mechanical properties, the effects of temperature and strain rate on the mean values of flow energy and crushing energy are summarized in Tables 22 and 23. As expected, Table 22 shows the flow energy to be independent of strain rate, and Table 23 shows the crushing energy to increase with increasing strain rate.

STRESS-ENERGY PAIRS

Earlier, we saw that the two stress quantities, σ_M and σ_R, are related to the total energy, and that relationship depends on temperature and strain rate. In the previous section, the total energy has been decomposed into rate dependent and rate independent parts via the quantities I_C and I_F. With this decomposition, we can now create two conjugate stress-energy pairs which provide correlations independent of strain rate.

The first conjugate pair is formed from the rate dependent stress and energy quantities. In Figures 19 and 20, we plot σ_M as a function of I_C for the two levels of temperature. Figure 19 shows that there is a correlation between σ_M and I_C and that the correlation is independent of strain rate. A linear regression line is calculated for all points in Figure 19 and is found to be statistically significant with a R^2 value of 0.946. Figure 20 does not present such a strong argument for a σ_M vs I_C relationship independent of strain rate. The data points in this figure form two widely separated clusters of points according to strain rate. In this situation, we are guaranteed a good fit between the two clusters, but this does not necessarily mean that the clusters are correlated. Despite this fact, a regression line is calculated for the combined points in Figure 20, and, as expected, the regression line is statistically significant with a R^2 value of 0.929.

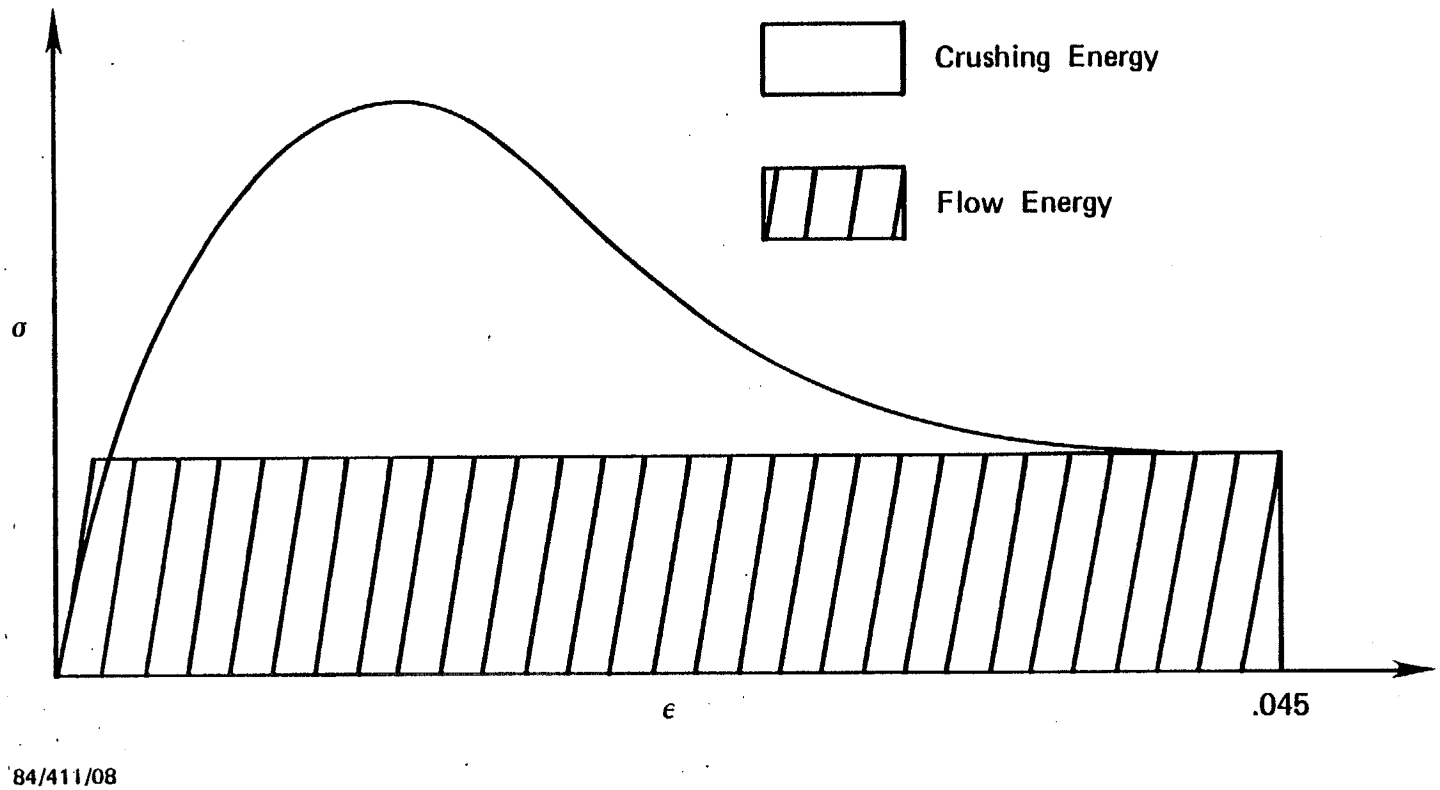

Fig. 18 - Schematic representation of flow energy and crushing energy.

Table 22

SUMMARY OF MEAN VALUES FOR I_F (in-lbf)/in^3

$\dot{\epsilon}$ \ T	-5°C	-20°C
10^{-5}/sec	8.92±1.97 61	11.12±3.16 29
10^{-3}/sec	42 7.96±2.56	18 11.46±3.39

Table 23

SUMMARY OF MEAN VALUES FOR I_C (in-lbf)/in^3

$\dot{\epsilon}$ \ T	-5°C	-20°C
10^{-5}/sec	1.27±0.89 61	1.59±0.82 29
10^{-3}/sec	42 5.78±1.50	18 10.89±2.13

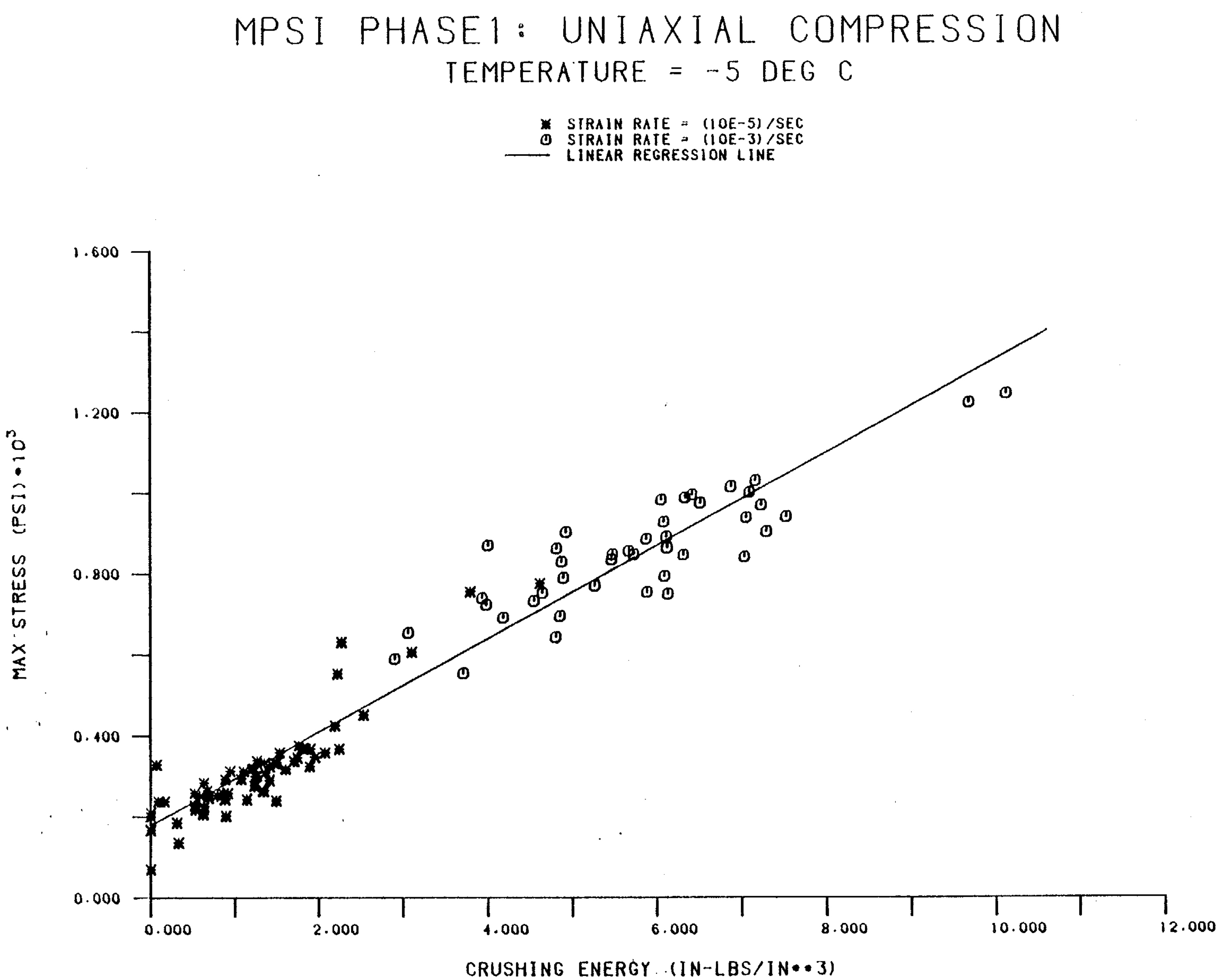

Fig. 19 - Maximum stress as a function of the crushing energy for T = -5°C.

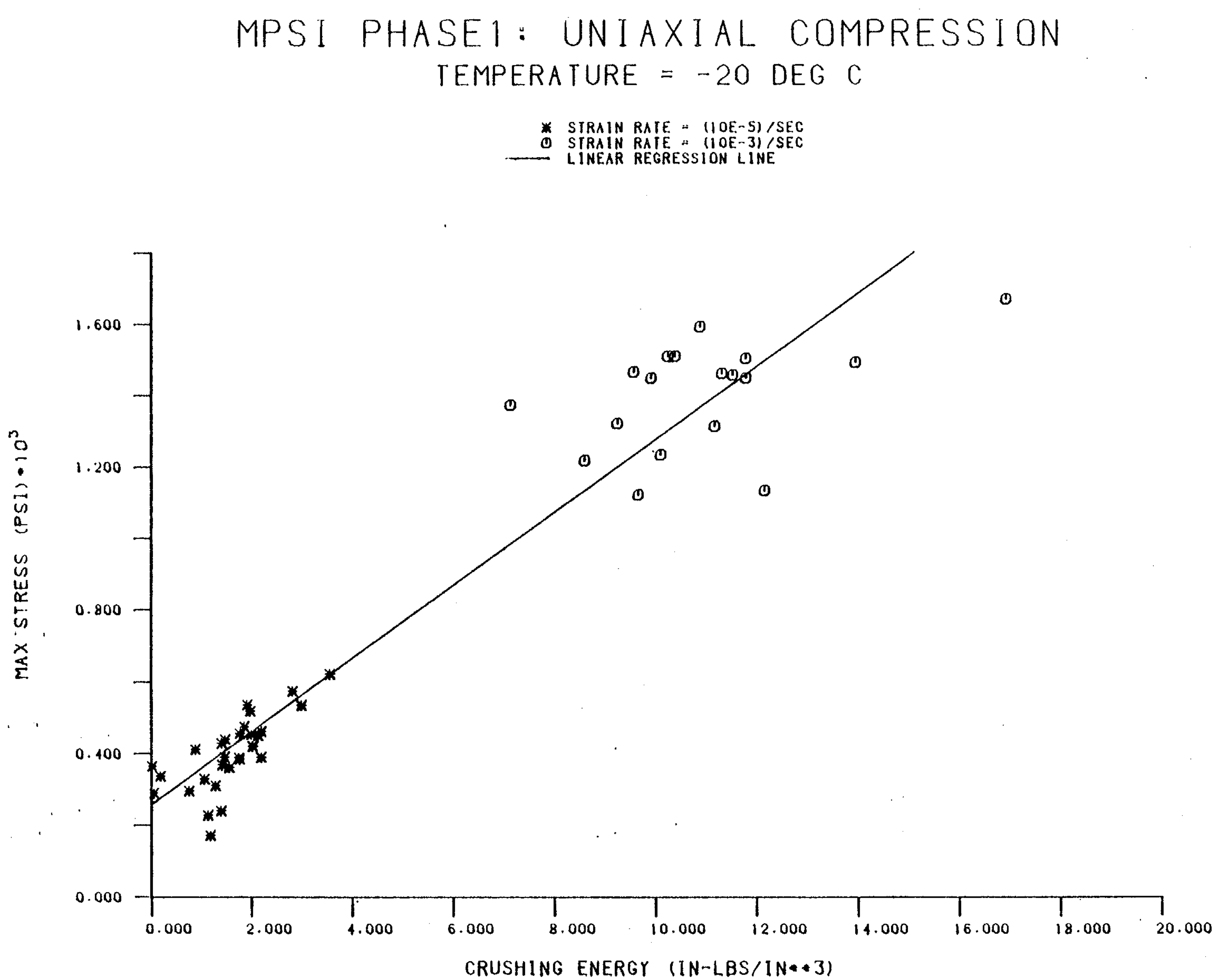

Fig. 20 - Maximum stress as a function of the crushing energy for T = -20°C.

The parameters for the regression lines in Figures 19 and 20 are summarized in Table 24. It is interesting to note that the intercepts for each line correspond closely to the mean residual stress for that temperature. This suggests that at a given temperature, the ratio $(\sigma_M - \sigma_R)/I_C$ is independent of strain rate. A comparison of the linear coefficients of the regression lines in Table 24 shows that they are in close agreement. This suggests that the only effect temperature has on the σ_M vs I_C relationship is to translate the regression line up or down by changing the temperature dependent value of the intercept σ_R. Comparison of Figures 19 and 20 with Figures 7 and 8 shows that the subtraction of the rate independent flow energy from the total energy eliminates the translation of regression lines in Figures 7 and 8. This results in a single relationship between I_C and σ_M independent of strain rate.

The second conjugate pair is formed from the rate independent stress and energy quantites. In Figures 21 and 22, we plot σ_R as a function of I_F for each temperature. The resulting, almost exact correlation between σ_R and I_F in both figures is to be expected from our definition of the flow energy. The important point to note is that the data points for each strain rate have very similar distributions along the σ_R vs I_F line lending further support for the rate independence of σ_R and I_F. The strain rate dependent translations for the regression lines seen in Figures 9 and 10 are again eliminated from Figures 21 and 22 by subtracting the rate dependent crushing energy from the total energy.

The equation defining the flow energy can be considered a regression line relating σ_R and I_F with a R^2 value of 1.0. The parameters for this line are summarized in Table 24. This table serves the same purpose as Table 19 by relating stress and energy quantities. However, in Table 19, σ_M and σ_R are functions of the total energy whereas in Table 24, the dependent and independent variables are rate dependent and rate independent conjugate pairs of stress and energy. The number of regression lines in Table 24 have been reduced by a factor of two since the dependence on strain rate has been eliminated. Comparison of the R^2 values in both tables indicates that the decomposition of the independent variable, I_T, into rate dependent and rate independent components significantly reduces the scatter in the dependent variables σ_M and σ_R.

Table 24

LINEAR REGRESSION MODELS BASED ON
CRUSHING ENERGY AND FLOW ENERGY

Independent Variable	Dependent Variable	Test Conditions	Linear Coefficient	Intercept	R^2
I_C	σ_M	C55, C35	114.97	179.84	.95
I_C	σ_M	C520, C320	102.03	260.63	.93
I_F	σ_R	C55, C35	$1/2\left(.09 - \frac{\sigma_R}{E_T}\right)\sigma_R$	0.0	1.0
I_F	σ_R	C520, C320	$1/2\left(.09 - \frac{\sigma_R}{E_T}\right)\sigma_R$	0.0	1.0

Table 25

SUMMARY OF MEAN VALUES FOR I_C/I_F

$\dot{\epsilon}$ \ T	-5°C	-20°C
10^{-5}/Sec	.138±.089 61	.157±.093 29
10^{-3}/sec	42 .822±.400	18 1.088±.571

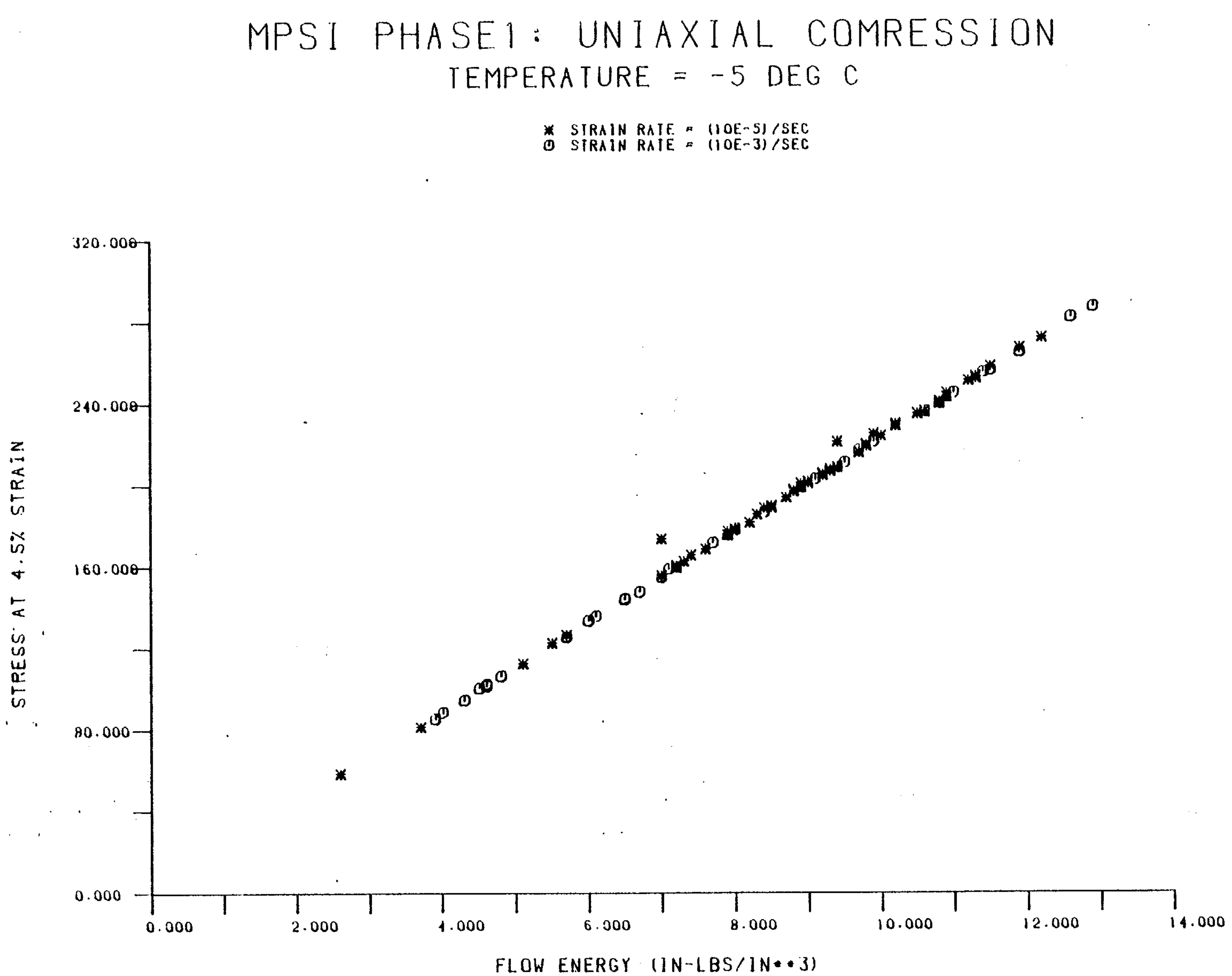

Fig. 21 - Stress at 4.5% strain as a function of the flow energy for T = -5°C.

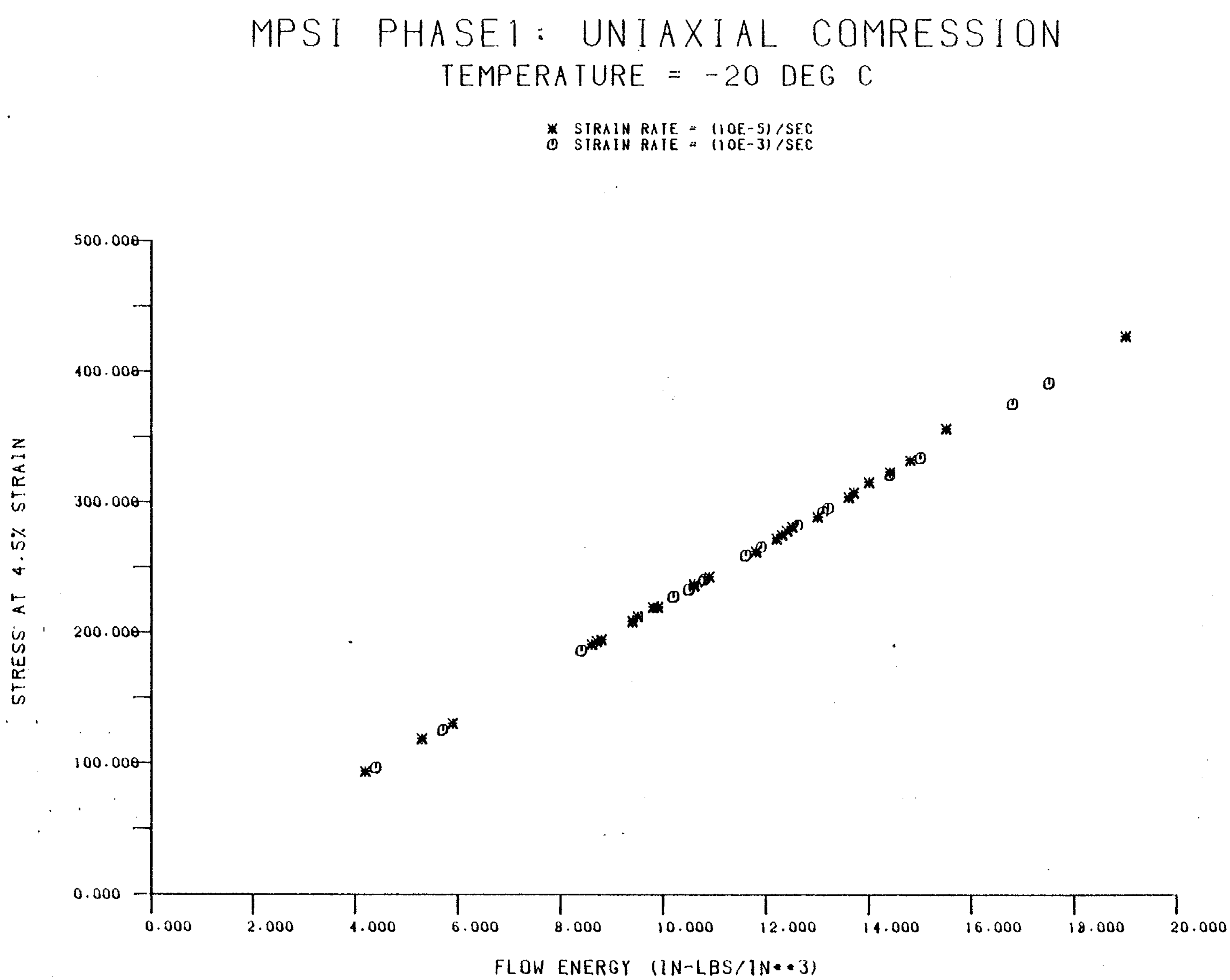

Fig. 22 - Stress at 4.5% strain as a function of the flow energy for T = -20°C.

A PARAMETER FOR CHARACTERIZING THE STRESS-STRAIN RESPONSE OF MULTI-YEAR RIDGE ICE

The quantities I_C and I_F can now be combined to yield a parameter which describes quantitatively the ductility or brittleness of a given stress-strain curve. From Figure 18 we see that the "hump" of the stress-strain curve is described by the crushing energy which measures the amount of energy in excess of the flow energy. By calculating the ratio, I_C/I_F, we can identify with each stress-strain curve a number which represents its shape. A stress-strain curve with a low crushing energy relative to its flow energy would have a low I_C/I_F value and would be classified as ductile. A curve with a high crushing energy relative to its flow energy would have a high I_C/I_F value and would be classified as brittle.

In practice it is not very practical to calculate the quantity I_C/I_F. A quantity easier to calculate and serving the same purpose as I_C/I_F would be desirable. From Figures 19 and 20 we see that the crushing energy is proportional to $(\sigma_M - \sigma_R)$ and by definition the flow energy is proportional to σ_R. Thus, the ratio $(\sigma_M - \sigma_R)/\sigma_R$ would be proportional to I_C/I_F and would provide another quantitative measure of ductility or brittleness. Figures 23 and 24 illustrate the relation between I_C/I_F and $(\sigma_M - \sigma_R)/\sigma_R$ for each temperature.

By taking the limiting values of I_C/I_F and $(\sigma_M - \sigma_R)/\sigma_R$, we see that in the limit these ratios represent the stress-strain curves of the material models shown in Figure 17. When I_C/I_F and $(\sigma_M - \sigma_R)/\sigma_R$ equals zero, we have $I_C = 0$ and $\sigma_M = \sigma_R$. In this case the stress-strain curve would resemble a perfectly plastic material. When I_C/I_F and $(\sigma_M - \sigma_R)/\sigma_R$ become unbounded, we have $I_F = \sigma_R = 0$ and the stress-strain curve would resemble a brittle elastic material.

The mean values of the ratio, I_C/I_F, are summarized for each test condition in Table 25. This table shows that the ratio increases with increasing strain rate and is independent of temperature. The temperature independence is due to the proportional increases in the values of σ_M and σ_R with the decrease in temperature resulting in a relatively constant value of I_C/I_F. Thus, a change in temperature causes a proportional change in the shape of the stress-strain curve whereas a change in strain rate will distort the shape of the stress-strain curve. To illustrate the effects of temperature and strain rate on the mechanical response and the variability of

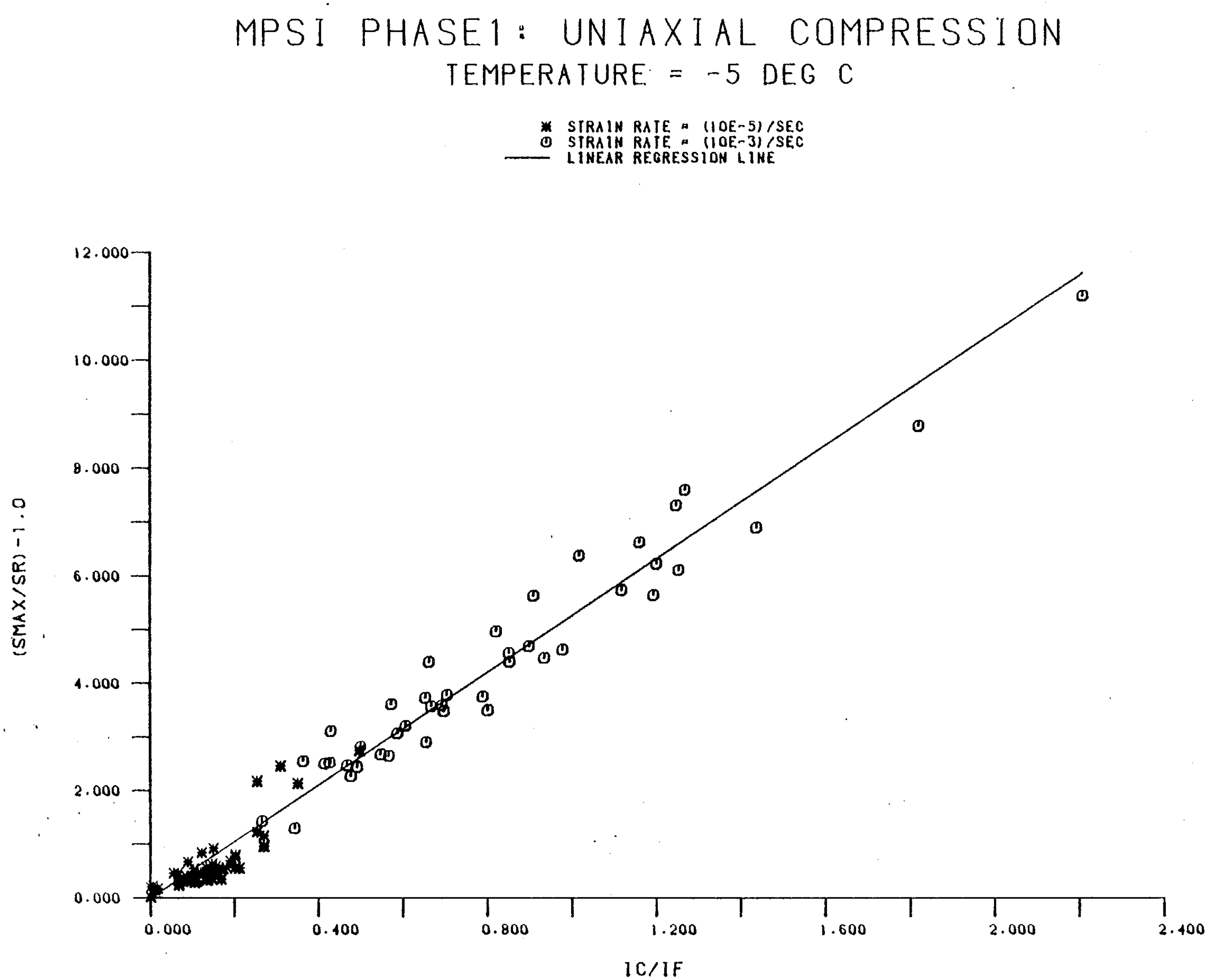

Fig. 23 - $\frac{\sigma_M - \sigma_R}{\sigma_R}$ as a function of I_C/I_F for T = -5°C.

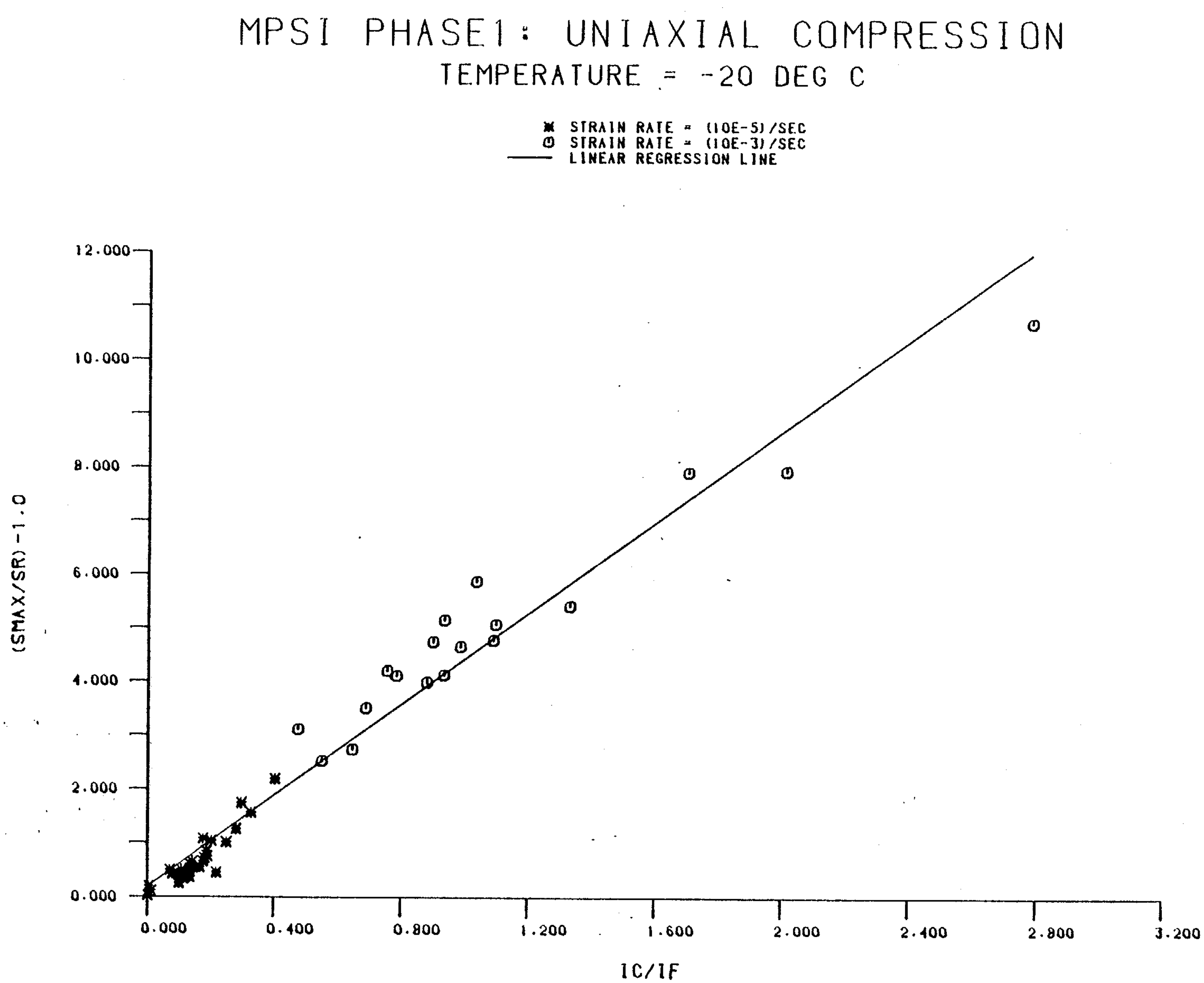

Fig. 24 - $\frac{\sigma_M - \sigma_R}{\sigma_R}$ as a function of I_C/I_F for T = -20°C.

the response within a given test condition, we choose the tests with maximum, minimum, and mean values of I_C/I_F at each test condition. The stress-strain curves for these tests are shown in Figures 25-28 according to test condition. The remaining stress-strain curves can be found in Appendix C according to test conditions. The splines for each force-time history are listed in Appendix B.

"AVERAGE" STRESS-STRAIN CURVES

Finally, we would like to establish a method of defining a stress-strain curve which in some sense represents the average response of multi-year ice at each test condition. The most obvious method of doing this would be to calculate point by point averages of all stress-strain curves within each test condition and then plot those average values to obtain an average stress-strain curve. This was done for each test condition, and the resulting curves are shown in Figures 29 and 30 for T = -5°C and T = -20°C, respectively.

A much easier method of selecting an average curve would be to compare the primary mechanical properties of each test with the corresponding mean values. The "error" associated with each property is its difference from the mean. In order to compare the errors associated with the different properties, each error should be normalized with respect to the mean value. If the errors of each property are to be summed for each test, then each normalized error should be squared. Thus, we can calculate a residual error from the mean for each test from the equation,

$$E^2 = \sum_{j=1}^{5} \left(\frac{x_j - \bar{x}_j}{\bar{x}_j} \right)^2$$

Here j denotes each of the five primary properties and the quantities x_j and $\bar{x}_j$ denote the actual and mean values, respectively, of the jth property. The residual errors for each test are summarized in Tables 26-29. The "average" stress-strain curve can now be chosen to be the curve with the minimum or least square of the residual error. The "average" curves chosen by the least squares method are shown in Figures 31 and 32.

A residual error for each curve obtained by pointwise averaging can also be calculated. These errors are listed in Table 30 along with the least

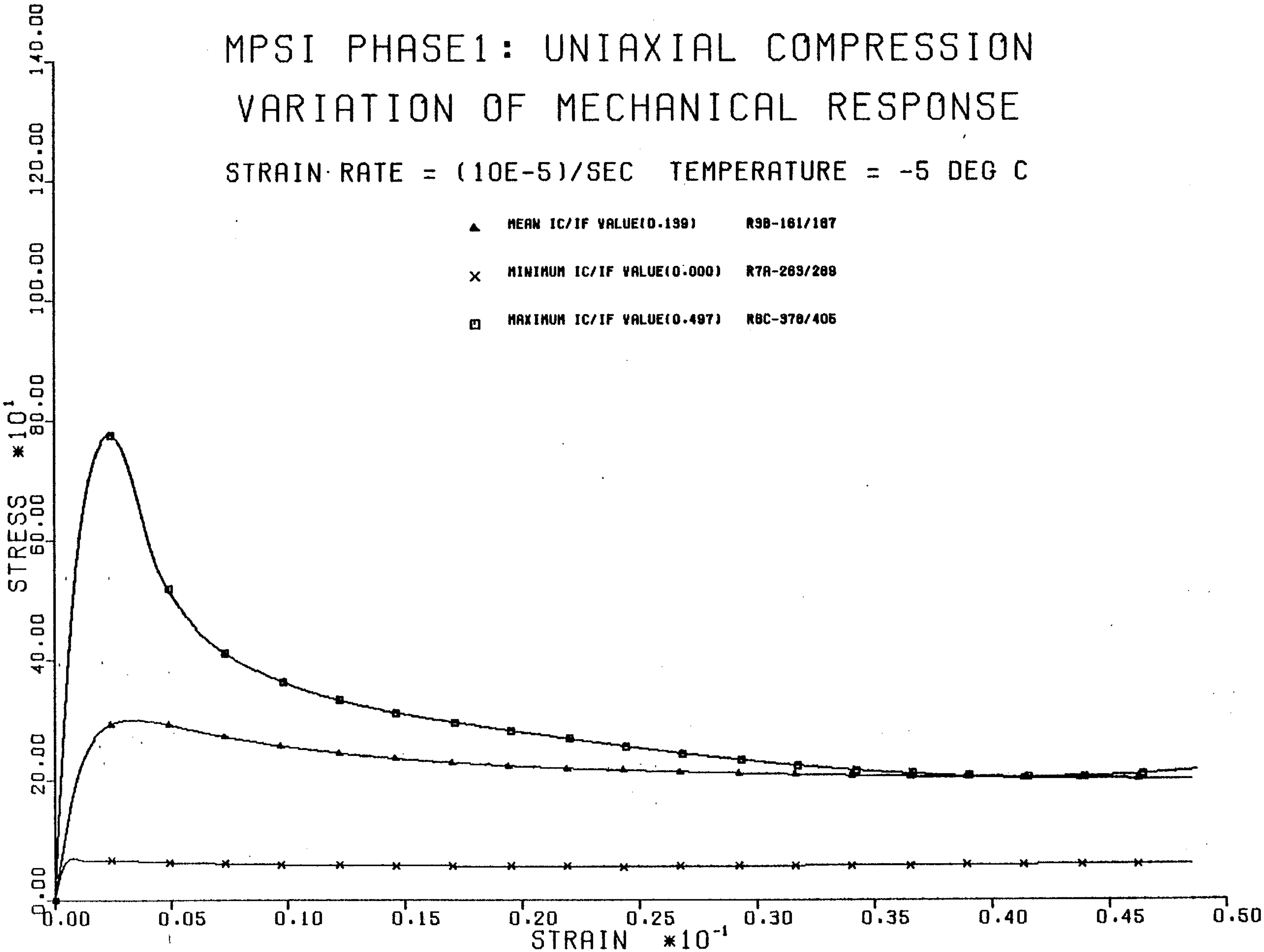

Fig. 25 - Variation of the mechanical response of multi-year ridge ice for $\dot{\varepsilon} = 10^{-5}$/sec and T = -5°C.

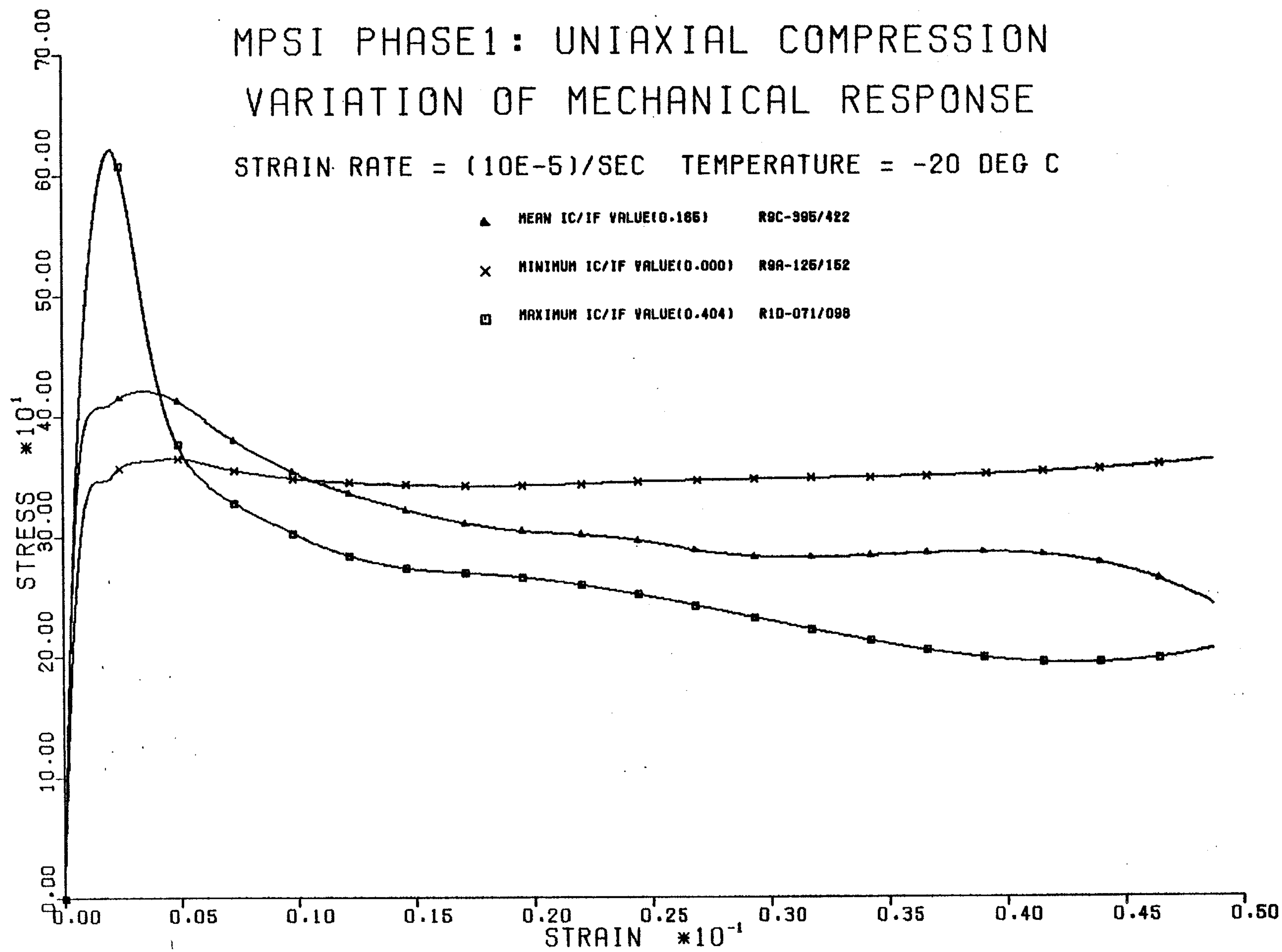

Fig. 26 - Variation of the mechanical response of multi-year ridge ice for $\dot{\varepsilon} = 10^{-5}$/sec and T = -20°C.

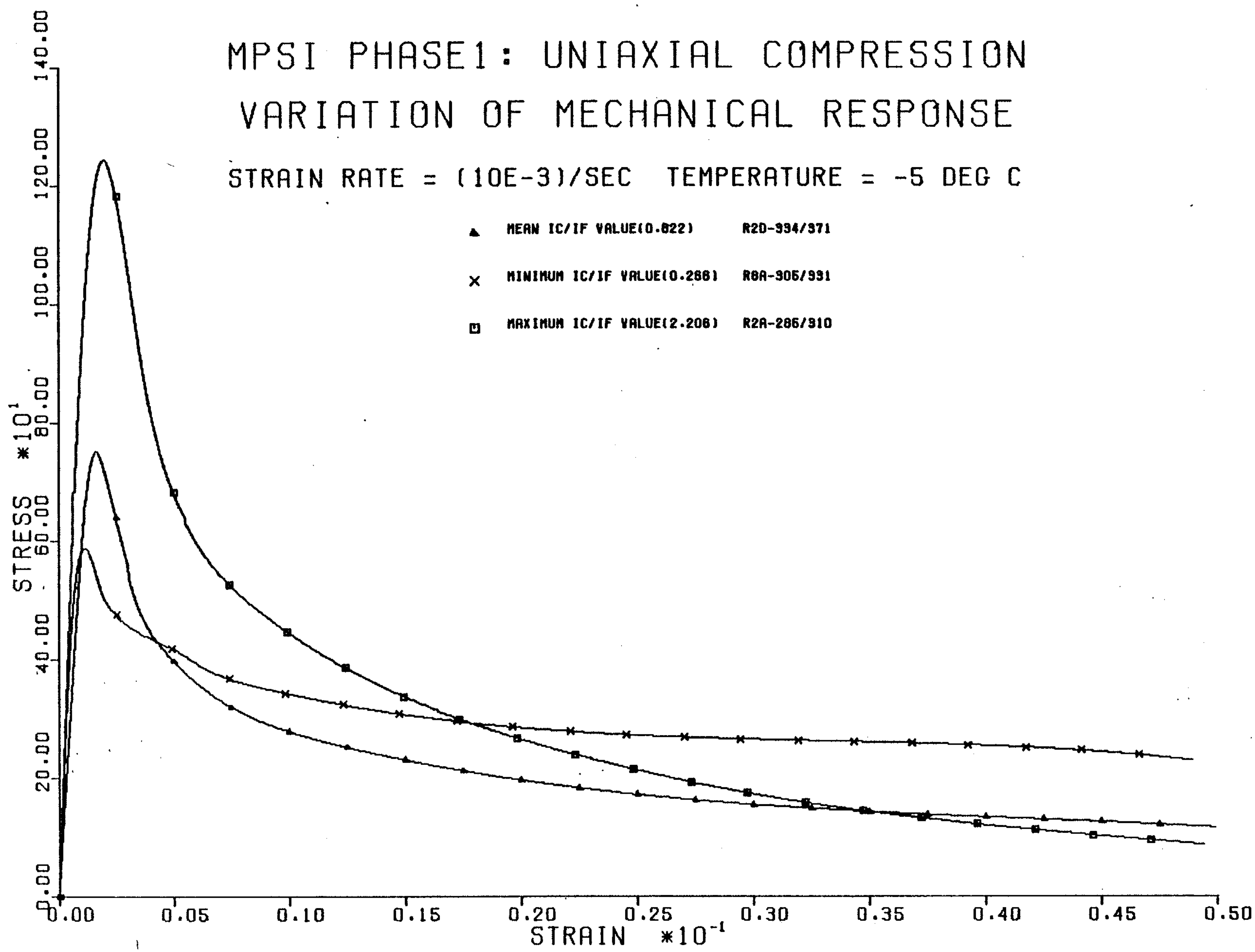

Fig. 27 - Variation of the mechanical response of multi-year ridge ice for $\dot{\varepsilon} = 10^{-3}$/sec and T = -5°C.

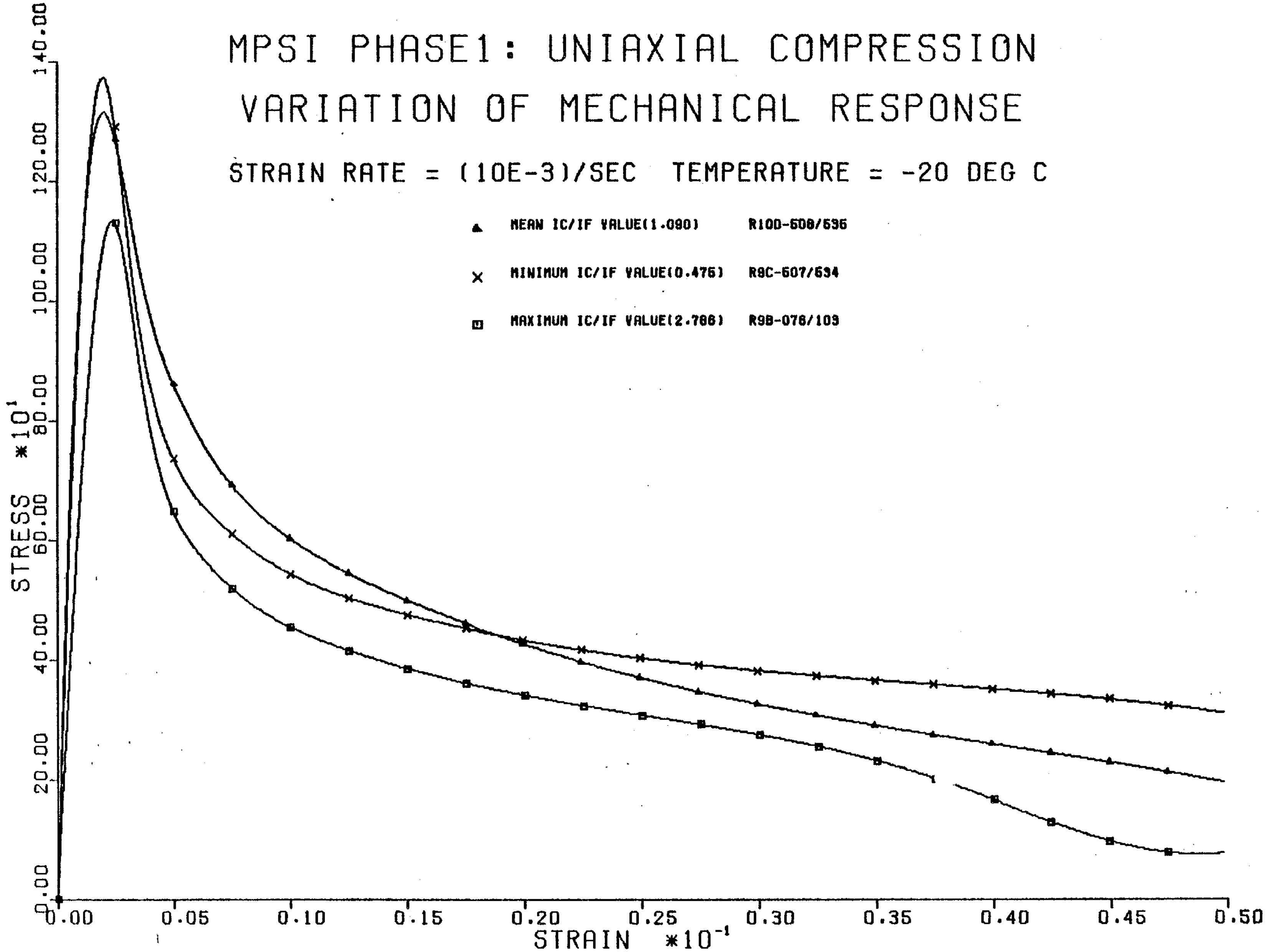

Fig. 28 - Variation of the mechanial response of multi-year ridge ice for $\dot{\varepsilon} = 10^{-3}$/sec and T = -20°C.

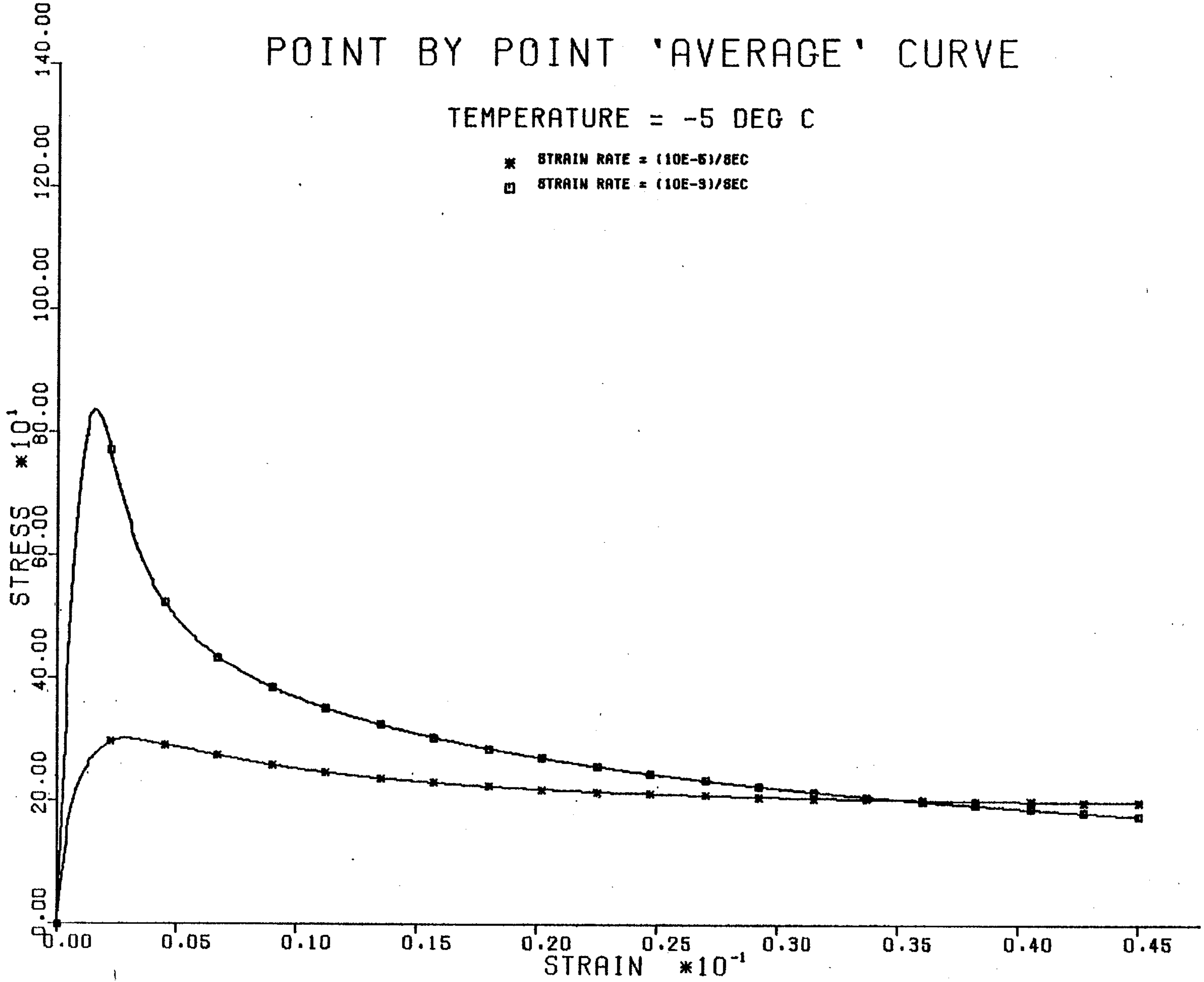

Fig. 29 - Point by point "average" stress-strain curve of multi-year ridge ice for $\dot{\varepsilon} = 10^{-5}$/sec and $\dot{\varepsilon} = 10^{-3}$/sec at T = -5°C.

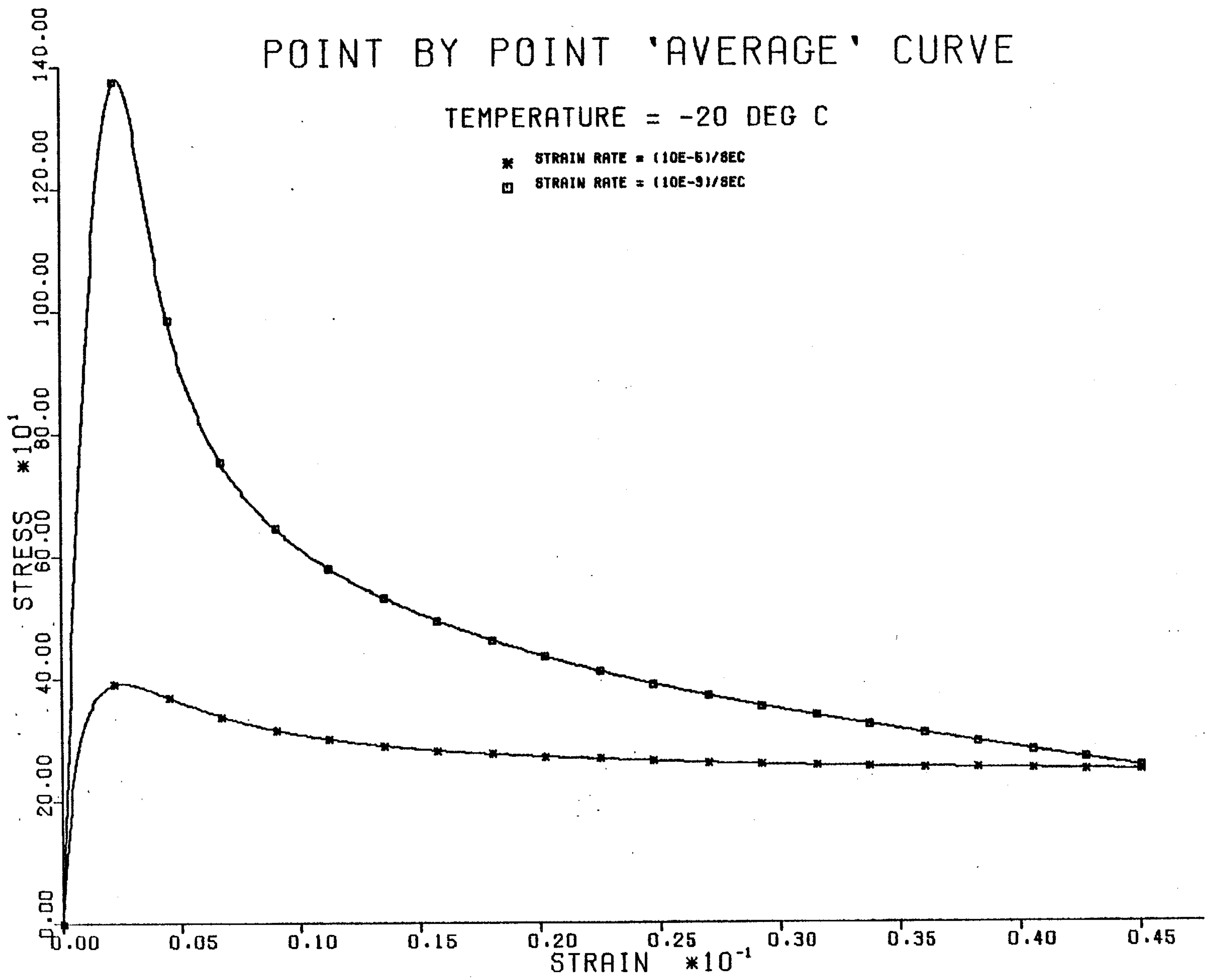

Fig. 30 - Point by point "average" stress-strain curve of multi-year ridge ice for $\dot{\varepsilon} = 10^{-5}$/sec and $\dot{\varepsilon} = 10^{-3}$/sec at T = -20°C.

Table 26

NORMALIZED ERRORS
STRAIN RATE = (10E-5)/SEC TEMPERATURE = -5°C

Ridge ID	I_C/I_F	σ_M	Norm σ_M	ϵ_M	Norm ϵ_M	σ_R	Norm σ_R	E_T	Norm E_T	I_T	Norm I_T	Total Res
R1A-062/089	0.202	425.	1.344	0.344	0.860	241.	1.205	0.965	1.896	13.0	1.276	1.059
R1B-062/089	0.133	321.	1.015	0.463	1.157	205.	1.025	0.467	0.917	10.4	1.021	0.033
R2A-140/165	0.212	368.	1.164	0.597	1.492	236.	1.180	0.493	0.969	12.8	1.257	0.369
R2B-094/121	0.000	167.	0.528	0.142	0.355	174.	0.870	0.201	0.395	7.0	0.687	1.119
R3A-106/131	0.134	333.	1.053	0.461	1.152	245.	1.226	0.330	0.648	12.4	1.217	0.248
R3B-161/187	0.139	300.	0.949	0.335	0.837	201.	1.005	0.231	0.454	10.2	1.001	0.327
R4A-312/338	0.145	277.	0.876	0.481	1.202	189.	0.945	0.482	0.947	9.7	0.952	0.064
R4B-328/354	0.163	244.	0.772	0.497	1.242	156.	0.780	0.211	0.415	8.1	0.795	0.544
R5A-165/191	0.254	606.	1.917	0.229	0.572	272.	1.361	1.041	2.045	15.3	1.502	2.498
R5B-075/101	0.351	755.	2.388	0.219	0.547	241.	1.205	0.797	1.566	14.6	1.433	2.682
R7A-059/085	0.135	359.	1.136	0.545	1.362	252.	1.261	0.488	0.959	12.8	1.257	0.285
R7B-126/152	0.010	239.	0.756	0.452	1.130	206.	1.030	0.327	0.642	9.3	0.913	0.213
R8A-133/159	0.017	238.	0.753	0.335	0.837	202.	1.010	0.450	0.884	9.2	0.903	0.110
R8B-162/189	0.141	324.	1.025	0.433	1.082	224.	1.120	0.294	0.578	11.4	1.119	0.215
R3C-095/122	0.075	265.	0.838	0.483	1.207	201.	1.005	0.177	0.348	9.6	0.942	0.498
R3D-159/186	0.000	201.	0.636	0.841	2.102	198.	0.990	0.268	0.527	8.8	0.864	1.591
R5C-039/066	0.155	376.	1.189	0.435	1.087	253.	1.266	0.689	1.354	13.1	1.286	0.321
R5D-159/186	0.203	359.	1.136	0.599	1.497	230.	1.150	0.212	0.417	12.3	1.207	0.672
R6C-166/193	0.000	211.	0.667	0.337	0.843	221.	1.105	0.314	0.617	9.4	0.923	0.299
R8C-048/075	0.069	228.	0.721	0.234	0.585	169.	0.845	0.500	0.982	8.1	0.795	0.316
R8D-236/263	0.006	329.	1.041	0.254	0.635	267.	1.336	0.441	0.866	12.0	1.178	0.297
R1A-226/252	0.122	208.	0.658	0.204	0.510	113.	0.565	1.286	2.527	5.7	0.560	3.070
R1A-399/425	0.156	203.	0.642	0.234	0.585	127.	0.635	1.056	2.075	6.6	0.648	1.712
R2A-314/339	0.150	313.	0.990	0.257	0.643	163.	0.815	0.432	0.849	8.4	0.825	0.216
R2B-408/434	0.109	339.	1.072	0.607	1.517	258.	1.291	0.466	0.916	12.8	1.257	0.430
R2B-468/494	0.104	259.	0.819	0.380	0.950	194.	0.970	0.534	1.049	9.6	0.942	0.042
R3A-220/245	0.085	248.	0.784	0.342	0.855	178.	0.890	0.183	0.360	8.6	0.844	0.514

Table 26 (Cont'd.)

Ridge ID	I_C/I_F	σ_M	Norm σ_M	ε_M	Norm ε_M	σ_R	Norm σ_R	E_T	Norm E_T	I_T	Norm I_T	Total Res
R3A-430/456	0.135	301.	0.952	0.463	1.157	208.	1.040	1.045	2.053	10.6	1.041	1.139
R3B-363/389	0.168	369.	1.167	0.501	1.252	243.	1.215	0.499	0.980	12.7	1.247	0.199
R4A-426/452	0.203	318.	1.006	0.312	0.780	176.	0.880	0.661	1.299	9.5	0.933	0.156
R4B-391/417	0.103	293.	0.927	0.277	0.693	190.	0.950	0.708	1.391	9.4	0.923	0.261
R4B-449/475	0.118	244.	0.772	0.355	0.888	166.	0.830	0.282	0.554	8.3	0.815	0.327
R5A-397/423	0.137	309.	0.977	0.480	1.200	225.	1.125	0.135	0.265	11.3	1.109	0.608
R5A-442/468	0.270	451.	1.427	0.253	0.633	209.	1.045	0.624	1.226	11.9	1.168	0.398
R5A-504/530	0.123	319.	1.009	0.493	1.232	220.	1.100	0.232	0.456	11.0	1.080	0.367
R5B-398/423	0.105	294.	0.930	0.407	1.017	229.	1.145	0.344	0.676	11.3	1.109	0.143
R7A-263/289	0.000	71.	0.225	0.078	0.195	59.	0.295	0.234	0.460	2.6	0.255	2.593
R7A-342/368	0.310	553.	1.749	0.218	0.545	160.	0.800	0.542	1.065	9.4	0.923	0.818
R7B-241/267	0.087	226.	0.715	0.448	1.120	161.	0.805	0.185	0.363	7.8	0.766	0.594
R8A-164/190	0.066	259.	0.819	0.242	0.605	176.	0.880	0.387	0.760	8.4	0.825	0.291
R8A-432/458	0.254	631.	1.996	0.169	0.423	199.	0.995	0.866	1.701	11.2	1.099	1.827
R8B-333/359	0.146	335.	1.060	0.253	0.633	206.	1.030	0.936	1.839	10.6	1.041	0.845
R8B-515/541	0.173	338.	1.069	0.416	1.040	219.	1.095	0.449	0.882	11.5	1.129	0.046
R3C-380/407	0.055	186.	0.588	0.210	0.525	127.	0.635	0.278	0.546	6.0	0.589	0.903
R3D-219/246	0.070	252.	0.797	0.341	0.853	186.	0.930	0.316	0.621	8.9	0.874	0.227
R3D-287/314	0.134	334.	1.057	0.659	1.648	251.	1.256	0.328	0.644	12.7	1.247	0.675
R5C-219/246	0.161	290.	0.917	0.487	1.217	197.	0.985	0.248	0.487	10.2	1.001	0.317
R5C-282/309	0.101	257.	0.813	0.508	1.270	189.	0.945	0.295	0.580	9.3	0.913	0.295
R5D-225/252	0.181	368.	1.164	0.508	1.270	235.	1.175	0.387	0.760	12.4	1.217	0.235
R5D-294/321	0.203	325.	1.028	0.498	1.245	208.	1.040	0.461	0.906	11.2	1.099	0.081
R6A-562/589	0.067	219.	0.693	0.479	1.197	176.	0.880	0.327	0.642	8.4	0.825	0.306
R6C-529/556	0.147	368.	1.164	0.811	2.027	272.	1.361	1.039	2.041	14.0	1.374	2.437
R8C-378/405	0.497	775.	2.451	0.239	0.598	207.	1.035	0.762	1.497	13.9	1.364	2.650
R8C-476/503	0.089	137.	0.433	0.214	0.535	82.	0.410	0.190	0.373	4.0	0.393	1.647

Table 26 (Cont'd.)

Ridge ID	I_C/I_F	σ_M	Norm σ_M	ϵ_M	Norm ϵ_M	σ_R	Norm σ_R	E_T	Norm E_T	I_T	Norm I_T	Total Res
R8D-534/561	0.270	241.	0.762	0.200	0.500	123.	0.615	0.312	0.613	7.0	0.687	0.702
R9A-341/368	0.164	265.	0.838	0.488	1.220	182.	0.910	0.645	1.267	9.5	0.933	0.159
R9B-385/412	0.000	289.	0.914	0.701	1.752	0.	0.000	0.380	0.747	0.0	0.000	0.638
R9C-426/453	0.065	284.	0.898	0.468	1.170	216.	1.080	0.446	0.876	10.3	1.011	0.061
R10A-351/378	0.169	348.	1.101	0.685	1.712	258.	1.291	0.539	1.059	13.5	1.325	0.711
R10B-351/378	0.088	313.	0.990	0.415	1.037	240.	1.200	0.658	1.293	11.7	1.149	0.149
R10C-316/343	0.099	253.	0.800	0.366	0.915	179.	0.895	0.346	0.680	8.8	0.864	0.179
R10D-325/352	0.190	346.	1.094	0.317	0.792	205.	1.025	0.341	0.670	10.9	1.070	0.166

Table 27

NORMALIZED ERRORS
STRAIN RATE = (10E-5)/SEC   TEMPERATURE = -20°C

Ridge ID	I_C/I_F	σ_M	Norm σ_M	ϵ_M	Norm ϵ_M	σ_R	Norm σ_R	E_T	Norm E_T	I_T	Norm I_T	Total Res
R1C-065/092	0.298	574.	1.459	0.181	0.562	209.	0.840	2.364	3.426	12.2	0.961	6.316
R1D-071/098	0.404	622.	1.581	0.205	0.637	195.	0.784	1.164	1.687	12.3	0.969	0.990
R3C-128/155	0.101	429.	1.091	0.332	1.031	307.	1.234	0.457	0.662	15.1	1.189	0.214
R3D-129/156	0.004	291.	0.740	0.249	0.773	243.	0.977	0.392	0.568	10.9	0.858	0.326
R5D-121/148	0.071	412.	1.047	0.234	0.727	275.	1.105	0.848	1.229	13.2	1.039	0.142
R6A-461/488	0.107	330.	0.839	0.279	0.866	220.	0.884	0.447	0.648	10.9	0.858	0.201
R8C-165/192	0.135	518.	1.317	0.324	1.006	323.	1.298	0.568	0.823	16.4	1.291	0.306
R8D-192/219	0.142	475.	1.208	0.244	0.758	289.	1.161	0.909	1.317	14.8	1.165	0.256
R9A-125/152	0.000	365.	0.928	0.474	1.472	356.	1.431	0.564	0.817	15.5	1.220	0.495
R9B-043/070	0.012	338.	0.859	0.435	1.351	304.	1.222	0.966	1.400	13.8	1.087	0.360
R10A-195/222	0.133	312.	0.793	0.268	0.832	213.	0.856	0.400	0.580	10.8	0.850	0.291
R10D-157/184	0.114	369.	0.938	0.474	1.472	275.	1.105	0.493	0.714	13.7	1.079	0.325
R1C-210/236	0.187	385.	0.979	0.257	0.798	209.	0.840	0.408	0.591	11.1	0.874	0.250
R1C-240/266	0.180	451.	1.147	0.225	0.699	262.	1.053	2.312	3.351	13.9	1.094	5.650
R1D-209/236	0.281	534.	1.358	0.210	0.652	237.	0.952	0.633	0.917	13.6	1.071	0.263
R1D-315/342	0.191	229.	0.582	0.258	0.801	131.	0.526	0.521	0.755	7.0	0.551	0.700
R3D-250/277	0.104	440.	1.119	0.341	1.059	315.	1.266	0.381	0.552	15.5	1.220	0.337
R3D-318/345	0.134	454.	1.154	0.522	1.621	332.	1.334	0.442	0.641	16.8	1.323	0.755
R5C-328/355	0.250	390.	0.992	0.303	0.941	194.	0.780	2.768	4.012	10.9	0.858	9.142
R5D-255/282	0.116	390.	0.992	0.469	1.457	281.	1.129	0.397	0.575	14.0	1.102	0.416
R5D-325/352	0.175	462.	1.175	0.410	1.273	278.	1.117	0.436	0.632	14.6	1.150	0.277
R8C-508/535	0.328	241.	0.613	0.189	0.587	94.	0.378	0.347	0.503	5.6	0.441	1.267
R8D-477/504	0.219	173.	0.440	0.318	0.988	119.	0.478	0.331	0.480	6.5	0.512	1.095
R8D-565/592	0.203	389.	0.989	0.239	0.742	191.	0.768	0.610	0.884	10.3	0.811	0.170
R9B-449/476	0.080	297.	0.755	0.308	0.957	209.	0.840	0.440	0.638	10.1	0.795	0.261
R9C-395/422	0.165	421.	1.070	0.346	1.075	272.	1.093	0.735	1.065	14.2	1.118	0.037
R9D-317/344	0.145	362.	0.920	0.381	1.183	236.	0.948	0.504	0.730	12.1	0.953	0.117
R10A-320/347	0.177	457.	1.162	0.253	0.786	220.	0.884	0.533	0.772	11.6	0.913	0.145
R10B-418/445	0.100	536.	1.363	0.573	1.780	427.	1.716	0.423	0.613	20.9	1.646	1.819

Table 28

NORMALIZED ERRORS
STRAIN RATE = (10E-3)/SEC TEMPERATURE = -5°C

Ridge ID	I_C/I_F	σ_M	Norm σ_M	ϵ_M	Norm ϵ_M	σ_R	Norm σ_R	E_T	Norm E_T	I_T	Norm I_T	Total Res
R1B-131/157	1.253	1222.	1.389	0.211	1.476	172.	0.970	0.883	0.874	17.4	1.267	0.465
R3A-188/213	0.667	927.	1.054	0.140	0.979	203.	1.144	1.089	1.078	15.2	1.106	0.042
R3B-130/155	0.364	870.	0.989	0.123	0.860	245.	1.381	1.140	1.129	15.0	1.092	0.190
R4B-299/325	1.268	885.	1.006	0.126	0.881	103.	0.581	1.016	1.006	10.5	0.764	0.246
R2C-049/076	0.430	654.	0.743	0.145	1.014	159.	0.896	0.643	0.637	10.2	0.742	0.275
R2D-134/161	0.653	733.	0.833	0.149	1.042	155.	0.874	0.708	0.701	11.5	0.837	0.162
R4C-309/336	0.587	847.	0.963	0.209	1.462	208.	1.172	0.670	0.663	14.8	1.077	0.363
R6A-398/425	1.017	789.	0.897	0.135	0.944	107.	0.603	0.929	0.920	9.7	0.706	0.264
R6A-504/531	0.500	829.	0.942	0.175	1.224	217.	1.223	0.717	0.710	14.6	1.063	0.191
R7D-088/114	0.692	1014.	1.152	0.160	1.119	221.	1.246	1.772	1.754	16.8	1.223	0.717
R9C-080/107	0.428	902.	1.025	0.185	1.294	256.	1.443	0.833	0.825	16.4	1.194	0.351
R9D-082/109	1.247	847.	0.963	0.160	1.119	102.	0.575	0.791	0.783	10.3	0.750	0.306
R1B-216/241	0.704	856.	0.973	0.149	1.042	179.	1.009	0.953	0.944	13.7	0.997	0.006
R1B-243/268	0.909	982.	1.116	0.122	0.853	148.	0.834	1.257	1.245	12.7	0.924	0.128
R2A-285/310	2.206	1244.	1.414	0.193	1.350	102.	0.575	1.008	0.998	14.7	1.070	0.479
R2B-438/464	1.118	969.	1.101	0.152	1.063	144.	0.812	1.024	1.014	13.7	0.997	0.050
R3A-401/427	0.850	890.	1.012	0.123	0.860	160.	0.902	1.248	1.236	13.3	0.968	0.086
R3B-239/265	0.477	834.	0.948	0.133	0.930	255.	1.437	1.007	0.997	16.9	1.230	0.252
R3B-331/357	0.801	940.	1.068	0.152	1.063	209.	1.178	1.073	1.062	16.9	1.230	0.097
R4A-398/423	0.977	754.	0.857	0.161	1.126	134.	0.755	0.734	0.727	11.9	0.866	0.189
R4B-358/384	1.436	750.	0.852	0.142	0.993	95.	0.535	0.859	0.850	10.4	0.757	0.319
R5A-473/499	0.789	846.	0.962	0.144	1.007	178.	1.003	0.953	0.944	14.3	1.041	0.006
R5B-370/396	0.934	793.	0.901	0.130	0.909	145.	0.817	0.976	0.966	12.6	0.917	0.059
R7A-232/258	0.662	723.	0.822	0.145	1.014	134.	0.755	0.656	0.650	10.0	0.728	0.289
R8A-305/331	0.266	590.	0.671	0.113	0.790	243.	1.370	0.916	0.907	13.8	1.005	0.298
R8B-300/326	0.344	554.	0.630	0.260	1.818	241.	1.358	0.531	0.526	14.5	1.055	1.163
R2C-196/223	0.573	862.	0.980	0.145	1.014	187.	1.054	0.804	0.796	13.2	0.961	0.047

Table 28 (Cont'd.)

Ridge ID	I_C/I_F	σ_M	Norm σ_M	ϵ_M	Norm ϵ_M	σ_R	Norm σ_R	E_T	Norm E_T	I_T	Norm I_T	Total Res
R2C-278/305	0.468	691.	0.785	0.174	1.217	199.	1.122	0.618	0.612	13.1	0.954	0.261
R2D-334/371	0.820	752.	0.855	0.165	1.154	126.	0.710	0.657	0.650	10.3	0.750	0.314
R4C-414/441	0.415	740.	0.841	0.152	1.063	211.	1.189	0.854	0.846	13.4	0.975	0.090
R4C-512/539	1.819	841.	0.956	0.139	0.972	86.	0.485	1.011	1.001	10.9	0.793	0.311
R4D-495/522	0.000	631.	0.717	0.141	0.986	0.	0.000	0.704	0.697	0.0	0.000	0.172
R7C-143/170	0.567	1029.	1.170	0.220	1.538	282.	1.590	0.749	0.742	19.8	1.441	0.928
R7C-541/568	0.898	1001.	1.138	0.154	1.077	176.	0.992	1.035	1.025	15.0	1.092	0.034
R7D-223/250	0.655	938.	1.066	0.235	1.643	240.	1.353	0.632	0.626	17.8	1.296	0.770
R7D-312/339	0.606	994.	1.130	0.165	1.154	236.	1.330	0.867	0.858	17.0	1.237	0.226
R9A-445/482	1.200	643.	0.731	0.149	1.042	89.	0.502	0.685	0.678	8.8	0.641	0.555
R9C-332/359	0.697	695.	0.790	0.195	1.364	155.	0.874	0.584	0.578	11.8	0.859	0.390
R9D-249/276	1.160	770.	0.875	0.170	1.189	101.	0.569	0.687	0.680	9.8	0.713	0.421
R10A-269/296	0.492	987.	1.122	0.180	1.259	287.	1.618	0.947	0.938	19.2	1.398	0.625
R10B-274/301	0.548	974.	1.107	0.174	1.217	265.	1.494	0.932	0.923	18.4	1.339	0.423
R10D-231/258	1.193	903.	1.026	0.175	1.224	136.	0.767	0.874	0.865	13.4	0.975	0.124

Table 29

NORMALIZED ERRORS
STRAIN RATE = (10E-3)/SEC   TEMPERATURE = -20°C

Ridge ID	I_C/I_F	σ_M	Norm σ_M	ϵ_M	Norm ϵ_M	σ_R	Norm σ_R	E_T	Norm E_T	I_T	Norm I_T	Total Res
R6A-531/558	0.900	1217.	0.863	0.158	0.756	212.	0.830	1.489	1.312	18.1	0.810	0.241
R9B-076/103	2.786	1134.	0.804	0.240	1.148	97.	0.380	0.751	0.662	16.5	0.738	0.628
R9C-049/076	0.784	1509.	1.070	0.269	1.287	295.	1.155	0.925	0.815	23.6	1.056	0.149
R9D-150/177	0.935	1592.	1.129	0.224	1.072	259.	1.014	1.310	1.154	22.5	1.007	0.046
R10B-084/111	1.331	1493.	1.058	0.209	1.000	233.	0.912	1.392	1.226	24.4	1.092	0.071
R2C-226/253	1.036	1510.	1.071	0.249	1.191	220.	0.861	0.844	0.744	20.1	0.899	0.137
R2D-406/433	1.704	1122.	0.795	0.234	1.120	126.	0.493	0.719	0.633	15.3	0.685	0.547
R4C-482/509	0.688	1449.	1.027	0.220	1.053	321.	1.257	1.068	0.941	24.3	1.087	0.080
R4D-382/409	0.880	1457.	1.033	0.274	1.311	292.	1.143	0.803	0.707	24.6	1.101	0.214
R6C-559/586	1.097	1449.	1.027	0.255	1.220	239.	0.936	1.043	0.919	22.5	1.007	0.060
R7C-457/484	2.014	1669.	1.183	0.305	1.459	187.	0.732	0.848	0.747	25.3	1.132	0.398
R7D-254/281	0.550	1323.	0.938	0.294	1.407	375.	1.468	0.702	0.619	26.0	1.163	0.561
R7D-546/573	0.986	1503.	1.066	0.240	1.148	266.	1.041	0.959	0.845	23.7	1.060	0.056
R9C-507/534	0.475	1374.	0.974	0.199	0.952	334.	1.308	1.129	0.995	22.1	0.989	0.098
R10A-407/434	0.646	1462.	1.037	0.269	1.287	391.	1.531	0.797	0.702	28.8	1.289	0.537
R10B-449/476	0.755	1466.	1.039	0.230	1.100	282.	1.104	0.919	0.810	22.2	0.993	0.059
R10C-506/533	0.934	1235.	0.876	0.225	1.077	241.	0.943	0.758	0.668	20.9	0.935	0.139
R10D-508/535	1.090	1315.	0.932	0.199	0.952	228.	0.893	1.249	1.100	21.4	0.957	0.030

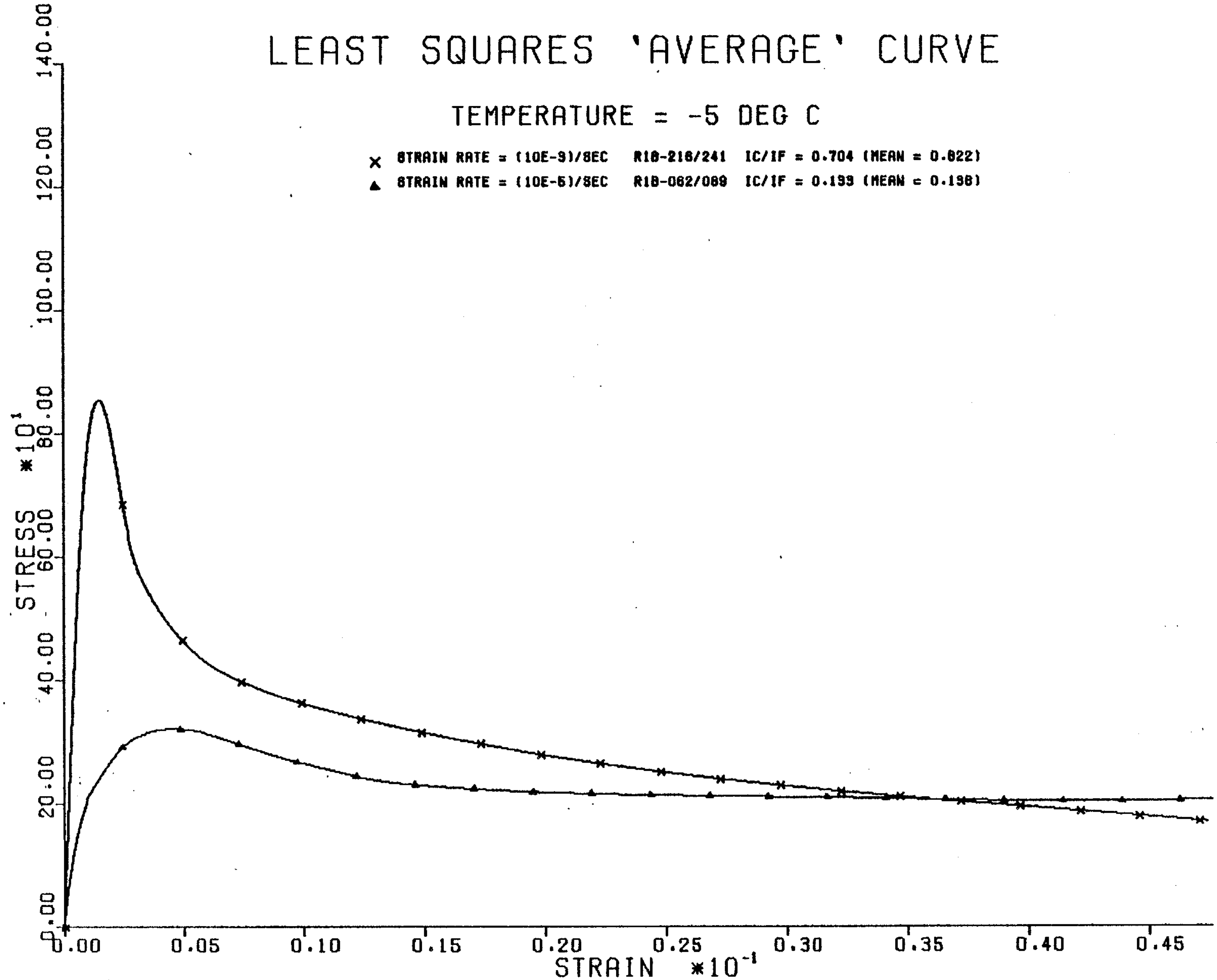

Fig. 31 - Least squares "average" stress-strain curve of multi-year ridge ice for $\dot{\varepsilon} = 10^{-5}$/sec and $\dot{\varepsilon} = 10^{-3}$/sec at T = -5°C.

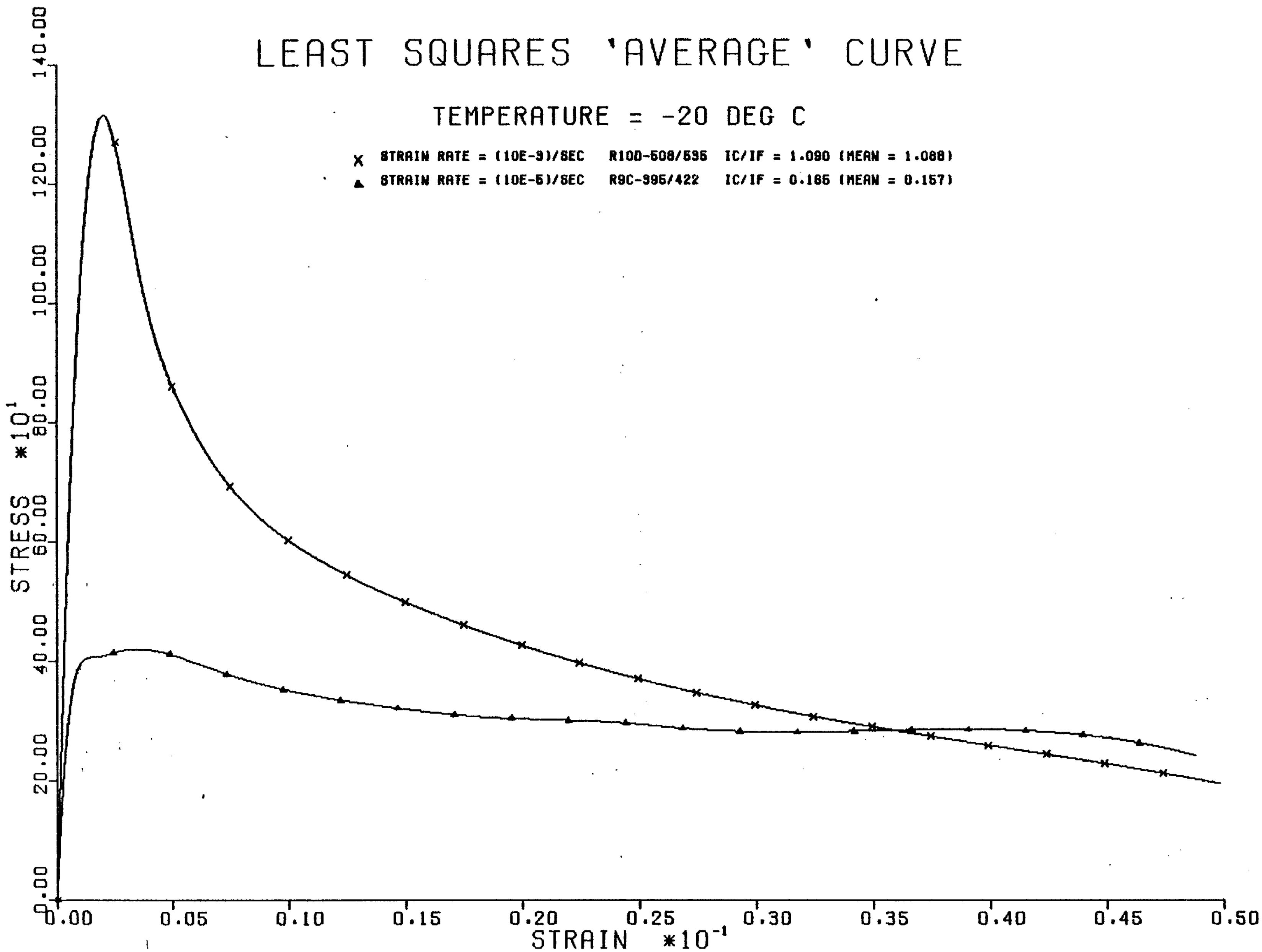

Fig. 32 - Least squares "average" stress-strain curve of multi-year ridge ice for $\dot{\varepsilon} = 10^{-5}$/sec and $\dot{\varepsilon} = 10^{-3}$/sec at T = -20°C.

Table 30

COMPARISON OF RESIDUAL ERROR
FOR THE TWO AVERAGING TECHNIQUES

Test Condition	Point by Point Averaging	Least Square Averaging
C55	.100	.033
C520	.060	.037
C35	.083	.006
C320	.046	.030

Table 31

STRUCTURAL CLASSIFICATION SCHEME FOR
MULTI-YEAR PRESSURE RIDGE ICE SAMPLES

Ice Type	Code	Structural Characteristics
Granular	1	Isotropic, equiaxed crystals
Columnar	2	Elongated, columnar grains
	2A	Columnar sea ice with c-axes normal to growth direction. Axes may not be aligned
	2B	Columnar sea ice having random c-axis orientation (Transition ice)
	2C	Columnar freshwater ice. May be either anisotropic or isotropic
Mixed	3	Combination of Types I and II
	3A	Largely Type II with granular veins
	3B	Largely Type I with inclusions of Type I or II ice (brecciated ice).

square error for each test condition. Comparison of the errors for each test condition shows that the least square method of selecting an average curve provides a better "average" since this method yields a curve which better reflects the average primary mechanical properties.

Tables 26-29 contain the values of I_C/I_F for each test in addition to the residual errors. These tables suggest that the quantity I_C/I_F provides another possible method of choosing an average stress-strain curve. Tests with low residual errors have values of I_C/I_F very close to the mean value of I_C/I_F.

PHYSICAL PROPERTIES

It is well documented in the literature (e.g., see Weeks and Ackley[9]) that the physical properties of ice significantly affect its mechanical response. The six physical properties most commonly recorded to characterize an ice sample are salinity, density, brine volume, air volume, total porosity, and crystal structure. The crystal structure of an ice sample depends greatly on the temperature and other environmental conditions at the time of crystallization. However, once the structure is formed, it can exist over a wide range of temperatures and can be considered independent of temperature. The other five properties are governed by the phase diagrams for solid seawater and consequently are functions of temperature. Frankenstein and Garner[10] have derived an equation relating salinity and brine volume in the temperature range from -2°C to -30°C. Over this same temperature range, Cox and Weeks[6] have derived equations to calculate the air volume if the salinity and density are known. Once the air volume is known, the total porosity can be calculated as the sum of the air and brine volumes. Thus, we see that of the five temperature dependent physical properties, only two are independent. Any two of these properties along with the crystal structure are sufficient to describe the effects of physical properties on the mechanical response of ice.

Given the temperature, it is easy to specify the temperature dependent physical properties from a few simple laboratory measurements and application of the equations referred to above. Specifying the crystal structure is not as straightforward since a classification scheme has to be developed which accounts for crystal shape (e.g., columnar, granular), c-axis orientation, and grain size. Previously, Cherepanov[11] and Michel[12] have devised classification schemes for undeformed ice, but these are not suitable for multi-year ridge ice. In addition to continuous regions of granular and columnar ice types, multi-year ridge ice can contain regions of discontinuous structure such as snow filled voids, block interfaces, and healed cracks. Richter and Cox[3] have developed a classification scheme to encompass all possible ice types in multi-year pressure ridges. Their scheme is summarized in Table 31 and is applied to high, intermediate, and low strength samples from test conditions C55 and C35 in Tables 32 and 33, respectively.

The salinity, density, brine volume, air volume, and porosity are listed for each test in Tables 34-37 according to test conditions. Since these properties depend on temperature, the data from the two pairs of test conditions with the same temperature can be combined into a single data file. Descriptive statistics are calculated for each of the combined data files and are summarized in Tables 38 and 39 for -5°C and -20°C, respectively. These two tables also contain a similar statistical summary of the properties of the samples tested at each strain rate. Comparison of the combined statistics with the statistics for each strain rate indicates that, on the average, the ice tested at different test conditions has the same temperature dependent physical properties.

To demonstrate the effect of physical properties on the mechanical properties, the maximum stress and initial tangent modulus are plotted as functions of the total porosity for each test condition in Figures 33-40. In each figure, a line is drawn to approximate an upper bound for the given mechanical property and test condition. These upper bounds show the maximum stress and initial tangent modulus to decrease with increasing porosity as one would expect. Since strength and the tangent modulus are known to decrease with increasing brine volume, the test samples with a brine volume of less than 5°/oo are distinguished from the others to investigate the possibility of those samples being the upper bound for those properties. The upper bound is determined by low brine volume samples in Figures 34 and 36, but brine volume alone does not determine the upper bound since low brine volume samples are also associated with lower bound values of strength and tangent modulus. Consideration of ice structure would probably explain the lower values of strength and tangent modulus associated with the low brine volume samples.

To demonstrate the effects of crystal structure, the data points having a crystallographic classification are identified in Figures 33, 35, 37,

Table 32

STRENGTH, STRUCTURE, AND POROSITY OF SELECTED RIDGE ICE SAMPLES*
TESTED AT $\dot{\varepsilon} = 10^{-5}$/SEC AND T = -5°C

Ridge ID	Strength (lbf/in^2)	Ice Type	Grain Size (mm)	Porosity (°/°°)
High Strength				
R1B-320/346	1090	2A-Aligned 0° Elongation	55 × 10	25.3
R5B-075/101	774	2A-Aligned 5° Elongation	17 × 6	72.3
R1B-429/455	696	2A 5° Elongation	15 × 10	23.7
R8A-432/458	657	2A-Aligned 5° Elongation	30 × 5	24.5
R5A-165/191	619	2A 0° Elongation	15 × 3	16.9
R7A-342/368	607	2C 0° Elongation	2 to 20	24.4
Intermediate Strength				
R3B-363/387	394	3B	< 1	15.3
R2A-140/165	388	1	2	10.1
R5B-341/367	368	1	< 1	56.1
R7A-059/082	361	1	< 1	69.5
R8B-515/541	348	2B	20 × 5	23.8
Low Strength				
R7B-241/267	229	3	5	77.8
R1A-226/252	214	2A 40° Elongation	25 × 15	19.4
R1A-399/425	214	3	-	38.9
R2B-094/121	171	3B	< 1	143
R7A-263/286	68	3A 40° Elongation	35	154

* From Cox, et al.[1]

Table 33

STRENGTH, STRUCTURE, AND POROSITY OF SELECTED RIDGE ICE SAMPLES*
TESTED AT $\dot{\varepsilon} = 10^{-3}$/SEC AND T = -5°C

Ridge ID	Strength (lbf/in^2)	Ice Type	Grain Size (mm)	Porosity (°/₀₀)
High Strength				
R1A-300/326	1580	2A-Aligned 0° Elongation	55 × 10	20.3
R7B-440/466	1540	2A-Aligned 5° Elongation	45 × 10	32.0
R8B-483/509	1440	2A-Aligned 15° Elongation	50 × 15	25.6
R8A-384/410	1297	2A 0° Elongation	40 × 10	24.2
R2A-285/310	1270	2A 10° Elongation	25 × 15	22.3
R1A-175/201	1270	2A 80° Elongation	-	16.2
R5B-141/167	1270	2A 0° Elongation	45 × 25	21.1
Intermediate Strength				
R3B-331/357	971	3B	< 1	31.4
R3A-188/213	970	3	5	23.5
R3A-401/427	925	3	< 1	21.0
R1B-216/241	915	2A 40° Elongation	35 × 20	16.3
R4B-299/325	910	3	2 to 10	56.2
R4B-420/466	910	3A	35 × 10	53.0
Low Strength				
R8B-300/326	587	3	-	15.1
R7B-175/201	557	2C 50° Elongation	5	23.3
R7B-072/098	487	3	-	53.4
R2A-110/135	408	1	< 1	86.9
R8A-033/059	346	3	-	75.2

* From Cox, et al.[1]

Table 34

PHYSICAL PROPERTIES
STRAIN RATE = (10E-5)/SEC TEMPERATURE = -5°C

Ridge ID	Salinity Test SX (0/00)	Density Test SX (lb/ft^3)	Brine Volume (0/00)	Air Volume (0/00)	Porosity (0/00)	Ice Type
R1A-062/089	1.80	55.05	17.1	41.9	59.0	
R1B-062/089	0.30	54.54	2.8	48.4	51.3	
R2A-140/165	0.10	56.77	1.0	9.1	10.1	1
R2B-094/121	0.44	49.35	3.7	139.2	143.0	3B
R3A-106/131	0.60	55.61	5.8	30.1	35.9	
R3B-161/187	1.13	56.92	11.1	8.1	19.2	
R4A-312/338	1.60	53.92	14.9	61.2	76.1	
R4B-328/354	1.57	56.11	15.2	22.9	38.1	
R5A-165/191	0.41	56.58	4.0	12.9	16.9	2A
R5B-075/101	1.80	54.26	16.9	55.5	72.3	2A
R7A-059/085	1.70	54.37	15.9	53.6	69.5	1
R7B-126/152	0.40	51.90	3.6	94.6	98.2	
R8A-133/159	1.00	55.95	9.7	24.8	34.5	
R8B-162/189	0.82	56.36	8.0	17.4	25.4	
R3C-095/122	0.54	54.87	5.1	42.9	48.0	
R3D-159/186	0.26	49.39	2.2	138.2	140.5	
R5C-039/066	1.27	53.10	11.6	75.0	86.6	
R5D-159/186	0.58	56.15	5.6	20.7	26.3	
R6C-166/193	0.45	50.74	3.9	114.8	118.8	
R8C-048/075	0.56	54.28	5.2	53.4	58.6	
R8D-236/263	0.50	54.74	4.7	45.1	49.8	
R1A-226/252	1.26	57.00	12.4	7.0	19.4	2A
R1A-399/425	2.40	56.62	23.4	15.4	38.9	3
R2A-205/230	0.38	55.32	3.6	35.0	38.6	
R2A-314/339	2.10	56.79	20.6	12.0	32.5	
R2B-408/434	0.80	55.82	7.7	26.9	34.6	
R2B-468/494	0.70	55.91	6.8	25.2	32.0	
R3A-220/245	1.61	57.06	15.8	6.5	22.3	
R3A-430/456	2.18	56.21	21.1	22.2	43.3	
R3B-363/389	0.89	56.99	8.7	6.5	15.3	3B
R4A-426/452	1.30	55.79	12.5	28.2	40.8	
R4B-391/417	2.27	56.42	22.1	18.7	40.8	
R4B-449/475	1.83	56.51	17.8	16.4	34.2	
R5A-397/423	0.80	56.44	7.8	16.0	23.8	
R5A-442/468	1.09	56.73	10.7	11.4	22.1	
R5A-504/530	1.23	56.47	12.0	16.1	28.1	
R5B-341/367	0.79	54.57	7.4	48.7	56.1	1
R5B-398/423	1.13	56.37	11.0	17.7	28.7	
R7A-263/289	3.03	50.22	26.3	127.6	153.9	3A
R7A-342/368	1.05	56.57	10.2	14.1	24.4	2C
R7B-241/267	1.30	53.63	12.0	65.8	77.8	3
R8A-164/190	1.20	56.45	11.7	16.4	28.1	
R8A-432/458	1.80	57.06	17.1	6.8	24.5	2A
R8B-333/359	1.50	57.04	14.8	6.7	21.4	

Table 34 (cont'd)

Ridge ID	Salinity Test SX (0/00)	Density Test SX (lb/ft^3)	Brine Volume (0/00)	Air Volume (0/00)	Porosity (0/00)	Ice Type
R8B-515/541	1.80	57.10	17.7	6.1	23.8	2B
R3C-296/323	1.62	55.91	15.6	26.5	42.2	
R3C-380/407	1.28	55.33	12.2	36.1	48.3	
R3D-219/246	1.28	53.43	11.8	69.3	81.1	
R3D-287/314	1.36	56.05	13.1	23.7	36.8	
R5C-219/246	1.29	55.67	12.4	30.2	42.6	
R5C-282/309	3.64	56.14	35.3	25.8	61.0	
R5D-225/252	1.37	56.35	13.3	18.5	31.8	
R5D-294/321	1.73	56.72	16.9	12.7	29.6	
R6A-562/589	2.38	54.01	22.2	60.9	83.1	
R6C-529/556	0.86	56.14	8.3	21.3	29.7	
R8C-378/405	1.44	56.77	14.1	11.3	25.4	
R8C-476/503	1.86	57.20	18.4	4.5	22.9	
R8D-446/473	1.95	56.62	19.0	14.7	33.8	
R8D-534/561	1.96	56.80	19.2	11.6	30.8	
R9A-341/368	0.65	53.71	6.0	63.5	69.5	
R9B-385/412	0.72	54.65	6.8	47.2	54.0	
R9C-426/453	1.08	56.31	10.5	18.7	29.2	
R9D-181/208	1.39	56.67	13.6	13.0	26.6	
R10A-351/378	0.27	56.75	2.6	9.8	12.4	
R10B-351/378	0.89	56.85	8.7	9.0	17.8	
R10C-316/343	2.89	56.58	28.2	17.0	45.2	
R10D-325/352	1.61	56.56	15.7	15.2	30.9	

Table 35

PHYSICAL PROPERTIES
STRAIN RATE = (10E-5)/SEC TEMPERATURE = -20°C

Ridge ID	Salinity Test SX (0/00)	Density Test SX (lb/ft^3)	Brine Volume (0/00)	Air Volume (0/00)	Porosity (0/00)	Ice Type
R1C-065/092	0.27	55.94	0.9	25.9	26.8	
R1D-071/098	0.61	56.61	2.0	14.6	16.6	
R3C-128/155	0.74	56.13	2.4	23.1	25.6	
R3D-129/156	0.14	49.65	0.4	135.4	135.8	
R5C-097/124	0.28	53.38	0.9	70.6	71.4	
R5D-121/148	0.53	55.91	1.7	26.7	28.5	
R6A-461/488	1.05	54.67	3.4	48.8	52.2	
R8C-165/192	0.88	54.44	2.8	52.7	55.5	
R8D-192/219	0.83	54.72	2.7	47.7	50.4	
R9A-125/152	0.04	50.96	0.1	112.5	112.6	
R9B-043/070	0.02	51.65	0.1	100.4	100.5	
R10A-195/222	0.53	56.20	1.7	21.7	23.4	
R10D-157/184	0.69	56.76	2.3	12.1	14.4	
R1C-210/236	1.10	55.40	3.6	36.1	39.7	
R1C-240/266	1.55	55.88	5.1	28.2	33.3	
R1D-209/236	0.99	56.01	3.2	25.4	28.6	
R1D-315/342	2.21	56.53	7.3	17.6	24.9	
R3C-329/359	1.69	55.94	5.5	27.4	32.9	
R3C-411/438	1.36	56.55	4.5	16.4	20.9	
R3D-250/277	1.59	55.85	5.2	28.8	34.0	
R3D-318/345	1.45	56.60	4.8	15.6	20.4	
R5C-250/277	1.55	56.55	5.1	16.6	21.7	
R5C-328/355	3.88	57.00	12.9	11.1	24.0	
R5D-255/282	1.69	56.22	5.5	22.5	28.5	
R5D-325/352	1.44	56.83	4.8	11.6	16.4	
R6A-661/688	2.83	54.39	9.0	55.4	64.4	
R6C-589/616	1.63	56.52	5.4	12.0	17.4	
R8C-444/471	1.48	56.56	4.9	16.4	21.3	
R8C-508/535	2.61	56.84	8.7	12.6	21.3	
R8D-477/504	1.95	57.10	6.5	7.4	14.0	
R8D-565/592	1.45	56.81	4.8	12.0	16.8	
R9A-523/550	0.81	55.83	2.6	28.4	31.1	
R9B-449/476	1.57	55.09	5.1	42.0	47.1	
R9C-395/422	1.09	55.77	3.6	29.7	33.3	
R9D-317/344	1.11	55.35	3.6	37.1	40.6	
R10A-320/347	1.23	56.92	4.1	9.9	14.0	
R10B-418/445	0.28	56.62	0.9	14.1	15.1	

Table 36

PHYSICAL PROPERTIES

STRAIN RATE = (10E-3)/SEC TEMPERATURE = -5°C

Ridge ID	Salinity Test SX (0/00)	Density Test SX (lb/ft^3)	Brine Volume (0/00)	Air Volume (0/00)	Porosity (0/00)	Ice Type
R1A-175/201	0.70	56.81	6.9	9.4	16.2	2A
R1B-131/157	0.37	56.82	3.6	8.7	12.3	
R2A-110/135	0.20	52.43	1.8	85.0	86.9	1
R2B-135/161	0.10	55.81	1.0	25.8	26.8	
R3A-188/213	1.40	56.85	13.7	9.8	23.5	3
R3B-130/155	1.13	56.28	11.0	19.3	30.3	
R4A-283/309	1.30	53.58	12.0	66.7	78.7	
R4B-299/325	1.30	54.89	12.3	43.9	56.2	3
R5A-135/161	0.20	56.10	1.9	20.9	22.9	
R5B-141/167	0.20	56.20	1.9	19.2	21.1	2A
R7A-005/031	0.02	52.92	0.2	76.2	76.4	
R7B-072/098	0.48	54.53	4.5	48.9	53.4	3
R8A-033/059	0.30	53.16	2.8	72.5	75.2	3A
R8B-011/037	0.10	52.48	0.9	84.0	84.9	
R2C-049/076	0.17	49.93	1.5	130.6	132.1	
R2D-134/161	0.37	52.64	3.4	81.5	84.8	
R4C-244/271	2.58	56.13	25.0	24.3	49.2	
R4C-309/336	0.88	55.43	8.4	33.7	42.1	
R4D-228/255	2.51	55.90	24.2	28.1	52.3	
R7C-007/034	0.10	54.27	0.9	52.9	53.8	
R6A-398/425	0.88	52.18	7.9	90.4	98.3	
R6A-504/531	0.81	53.47	7.5	67.9	75.3	
R7D-088/114	0.64	55.33	6.1	35.1	41.2	
R9C-080/107	0.46	54.67	4.3	46.1	50.4	
R9D-082/109	0.41	53.72	3.8	62.9	66.7	
R1A-300/326	1.00	56.77	9.8	10.5	20.3	2A
R1B-216/241	1.20	57.14	11.8	4.4	16.3	2A
R1B-243/268	1.56	57.14	15.4	5.0	20.4	
R2A-285/310	0.70	56.46	6.8	15.5	22.3	2A
R2A-383/408	2.00	56.81	19.6	11.5	31.1	
R2B-351/377	2.46	56.37	23.9	19.8	43.8	
R2B-438/464	2.70	56.48	26.3	18.3	44.6	
R3A-401/427	1.45	57.03	14.3	6.8	21.0	3
R3B-239/265	2.00	57.13	19.7	5.9	25.6	
R3B-331/357	2.00	56.79	19.6	11.8	31.4	3B
R4A-398/423	1.30	56.03	12.6	23.2	36.5	
R4B-358/384	1.96	56.00	18.9	25.5	44.4	
R4B-420/446	3.30	56.39	32.2	20.8	53.0	3A
R5A-473/499	0.91	55.75	8.8	28.3	37.1	
R5B-287/313	4.00	56.96	39.4	12.1	51.4	
R5B-370/396	1.26	55.09	12.0	40.4	52.3	
R7A-232/258	3.40	49.76	29.2	136.1	165.3	

Table 36 (cont'd)

Ridge ID	Salinity Test SX (0/00)	Density Test SX (lb/ft^3)	Brine Volume (0/00)	Air Volume (0/00)	Porosity (0/00)	Ice Type
R7A-295/321	0.95	54.09	8.9	57.3	66.1	
R7B-175/201	0.13	56.03	1.3	22.0	23.3	2C
R7B-440/466	2.48	57.08	24.4	7.6	32.0	2A
R8A-305/331	1.50	56.70	14.7	12.6	27.2	
R8A-384/410	1.70	57.01	16.7	7.5	24.2	2A
R8B-300/326	0.30	56.61	2.9	12.2	15.1	3
R8B-483/509	2.10	57.0	20.7	4.9	25.6	2A
R2C-196/223	1.04	55.35	9.9	35.4	45.3	
R2C-278/305	2.33	54.66	22.0	49.5	71.5	
R2D-220/247	0.37	54.65	3.5	46.7	50.1	
R2D-334/371	1.90	54.58	17.9	50.3	68.1	
R4C-414/441	3.03	56.76	29.7	14.1	43.7	
R4C-512/539	1.03	55.85	9.9	26.6	36.6	
R4D-495/522	2.92	57.16	28.8	6.9	35.7	
R6C-476/503	0.93	54.44	8.7	51.2	59.9	
R7C-143/170	0.77	56.27	7.5	18.9	26.4	
R7C-541/568	1.15	56.75	11.3	11.2	22.5	
R7D-223/250	2.04	55.49	19.5	34.5	54.0	
R7D-312/339	1.12	54.82	10.6	44.7	55.3	
R9A-445/482	1.05	54.01	9.8	58.8	68.6	
R9B-329/356	0.78	55.00	7.4	41.0	48.4	
R9C-332/359	0.83	54.98	7.9	41.5	49.3	
R9D-249/276	0.96	53.81	8.9	62.2	71.1	
R10A-269/296	0.81	56.39	7.9	16.9	24.8	
R10B-274/301	1.09	56.44	10.6	16.5	27.1	
R10C-445/472	1.99	56.71	19.5	13.2	32.7	
R10D-231/258	1.03	56.61	10.1	13.4	23.5	

Table 37

PHYSICAL PROPERTIES
STRAIN RATE = (10E-3)/SEC TEMPERATURE = -20°C

Ridge ID	Salinity Test SX (0/00)	Density Test SX (lb/ft^3)	Brine Volume (0/00)	Air Volume (0/00)	Porosity (0/00)	Ice Type
R1C-127/154	0.31	56.08	1.0	22.8	23.8	
R1D-153/178	1.00	56.20	3.3	22.1	25.4	
R2C-129/156	0.63	54.62	2.0	50.5	52.5	
R2D-095/122	0.20	53.22	0.6	73.3	73.9	
R4D-198/225	2.31	54.72	7.4	49.2	56.5	
R6A-531/558	1.22	54.37	3.9	54.2	58.1	
R6C-134/161	0.29	52.48	0.9	86.2	87.1	
R7C-092/119	0.82	55.89	2.7	27.4	30.1	
R7D-036/063	0.19	55.16	0.6	39.5	40.1	
R9A-071/098	0.04	50.93	0.1	113.0	113.1	
R9B-076/103	0.03	50.68	0.1	117.4	117.4	
R9C-049/076	0.38	54.81	1.2	45.8	47.0	
R9D-150/177	1.22	55.68	4.0	31.4	35.4	
R10A-238/265	0.81	56.58	2.7	15.4	18.0	
R10B-084/111	0.61	56.33	2.0	19.5	21.5	
R1C-349/375	3.42	56.71	11.3	15.6	27.0	
R1C-384/410	1.94	54.65	6.2	50.0	56.2	
R1D-179/206	1.03	56.63	3.4	14.7	18.1	
R1D-285/312	2.48	57.29	8.3	4.6	12.9	
R2C-226/253	0.89	54.80	2.8	46.4	49.3	
R2C-310/337	2.63	55.15	8.5	42.0	50.5	
R2D-265/292	3.01	55.25	9.7	40.6	50.3	
R2D-406/433	1.61	55.13	5.2	41.4	46.5	
R4C-482/509	1.28	55.92	4.2	27.3	31.5	
R4C-543/570	1.87	56.16	6.1	23.7	29.8	
R4D-382/409	1.15	56.45	3.8	18.0	21.8	
R4D-414/441	0.90	55.25	2.9	38.6	41.5	
R4D-525/552	0.88	56.19	2.9	22.2	25.1	
R6C-559/586	1.70	55.92	5.6	27.7	33.3	
R7C-457/484	1.32	57.04	4.4	7.9	12.3	
R7C-572/599	1.33	56.73	4.4	13.3	17.7	
R7D-254/281	1.21	55.62	3.9	32.5	36.4	
R7D-546/573	1.09	56.72	3.6	13.2	16.8	
R9A-424/451	0.68	54.00	2.1	60.1	62.3	
R9B-417/444	0.62	54.37	2.0	53.6	55.6	
R9C-507/534	1.86	56.77	6.2	13.1	19.3	
R9D-348/375	1.14	55.39	3.7	36.4	40.1	
R10A-407/434	0.22	56.68	0.7	13.0	13.8	
R10B-449/476	0.36	56.70	1.2	12.8	14.0	
R10C-506/533	3.65	57.02	12.2	10.5	22.7	
R10D-508/535	2.35	57.00	7.8	9.6	17.4	

Table 38

STATISTICAL SUMMARY OF PHYSICAL PROPERTIES OF ICE SAMPLES TESTED AT -5°C

Combined Strain Rates

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Kurtosis	Skewness	Variance	C.V.
Salinity	136	1.272	0.818	0.020	4.000	172.930	0.593	0.850	0.669	64.347
Density	136	55.436	1.742	49.350	57.200	7539.350	2.659	-1.638	3.033	3.141
Brine	136	12.224	7.899	0.200	39.400	1662.500	0.573	0.827	62.394	64.617
Airvol	136	34.272	30.095	4.400	139.200	4661.000	2.846	1.681	905.693	87.811
Porosity	136	46.501	29.020	10.100	165.300	6324.100	3.843	1.777	842.155	62.407

Strain Rate = (10E-5)/Sec

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Kurtosis	Skewness	Variance	C.V.
Salinity	67	1.280	0.710	0.100	3.640	85.790	0.980	0.803	0.504	55.441
Density	67	55.482	1.823	49.350	57.200	3717.270	3.476	-1.897	3.324	3.286
Brine	67	12.294	6.825	1.000	35.300	823.700	0.884	0.743	46.578	55.513
Airvol	67	33.488	31.584	4.500	139.200	2243.700	3.490	1.904	997.527	94.313
Porosity	67	45.794	30.837	10.100	153.900	3068.200	3.488	1.849	950.912	67.338

Strain Rate = (10E-3)/Sec

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Kurtosis	Skewness	Variance	C.V.
Salinity	69	1.263	0.916	0.020	4.000	87.140	0.271	0.868	0.840	72.563
Density	69	55.392	1.670	49.760	57.200	3822.080	1.915	-1.362	2.790	3.016
Brine	69	12.157	8.869	0.200	39.400	838.800	0.265	0.859	78.654	72.954
Airvol	69	35.033	28.787	4.400	136.100	2417.300	2.323	1.447	828.686	82.170
Porosity	69	47.187	27.350	12.300	165.300	3255.900	4.749	1.727	748.012	57.961

Table 39

STATISTICAL SUMMARY OF PHYSICAL PROPERTIES OF ICE SAMPLES TESTED AT -20°C

Combined Strain Rates

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Kurtosis	Skewness	Variance	C.V.
Salinity	78	1.229	0.856	0.020	3.880	95.830	1.004	0.990	0.733	69.683
Density	78	55.506	1.594	49.650	57.290	4329.470	3.473	-1.842	2.541	2.872
Brine	78	4.022	2.828	0.100	12.900	313.700	1.101	1.009	7.996	70.309
Airvol	78	34.397	27.448	4.600	135.400	2683.000	3.445	1.838	753.374	79.796
Porosity	78	38.429	26.298	12.300	135.800	2997.500	3.359	1.810	691.605	68.433

Strain Rate = (10E-5)/Sec

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Kurtosis	Skewness	Variance	C.V.
Salinity	37	1.220	0.808	0.020	3.880	45.150	2.158	1.059	0.653	66.220
Density	37	55.572	1.694	49.650	57.100	2056.180	4.618	-2.150	2.869	3.048
Brine	37	4.003	2.671	0.100	12.900	148.100	2.258	1.075	7.132	66.722
Airvol	37	33.149	29.217	7.400	135.400	1226.500	4.594	2.146	853.608	88.138
Porosity	37	37.173	28.036	14.000	135.800	1375.400	4.565	2.134	786.043	75.422

Strain Rate = (10E-3)/Sec

Variable	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Kurtosis	Skewness	Variance	C.V.
Salinity	41	1.236	0.907	0.030	3.650	50.680	0.497	0.965	0.823	73.398
Density	41	55.446	1.517	50.680	57.290	2273.290	2.762	-1.566	2.302	2.736
Brine	41	4.039	2.995	0.100	12.200	165.600	0.601	0.988	8.972	74.159
Airvol	41	35.524	26.062	4.600	117.400	1456.500	2.727	1.562	679.254	73.365
Porosity	41	39.563	24.922	12.300	117.400	1622.100	2.549	1.511	621.124	62.993

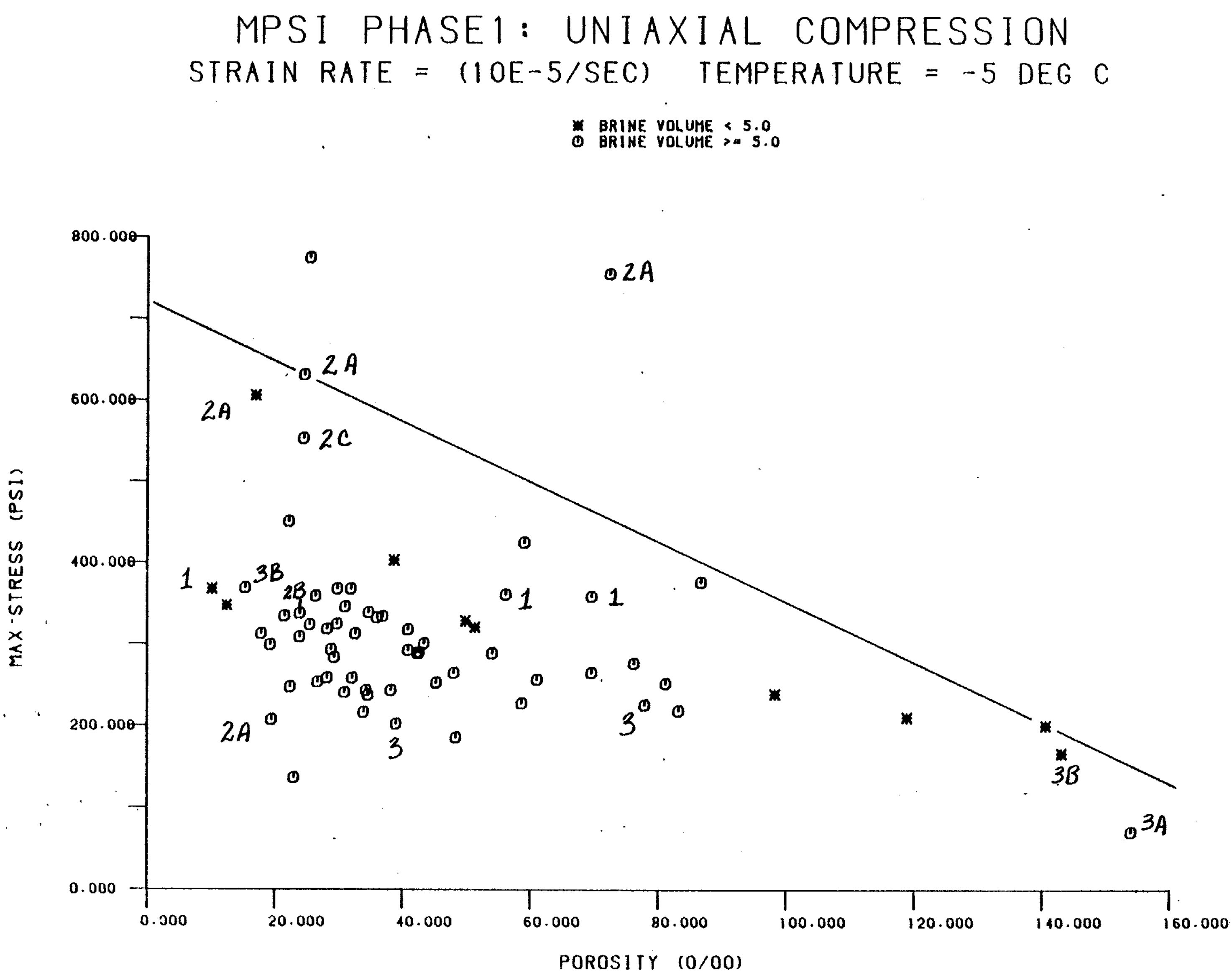

Fig. 33 - Maximum stress as a function of porosity for $\dot{\varepsilon} = 10^{-5}$/sec and $T = -5°C$.

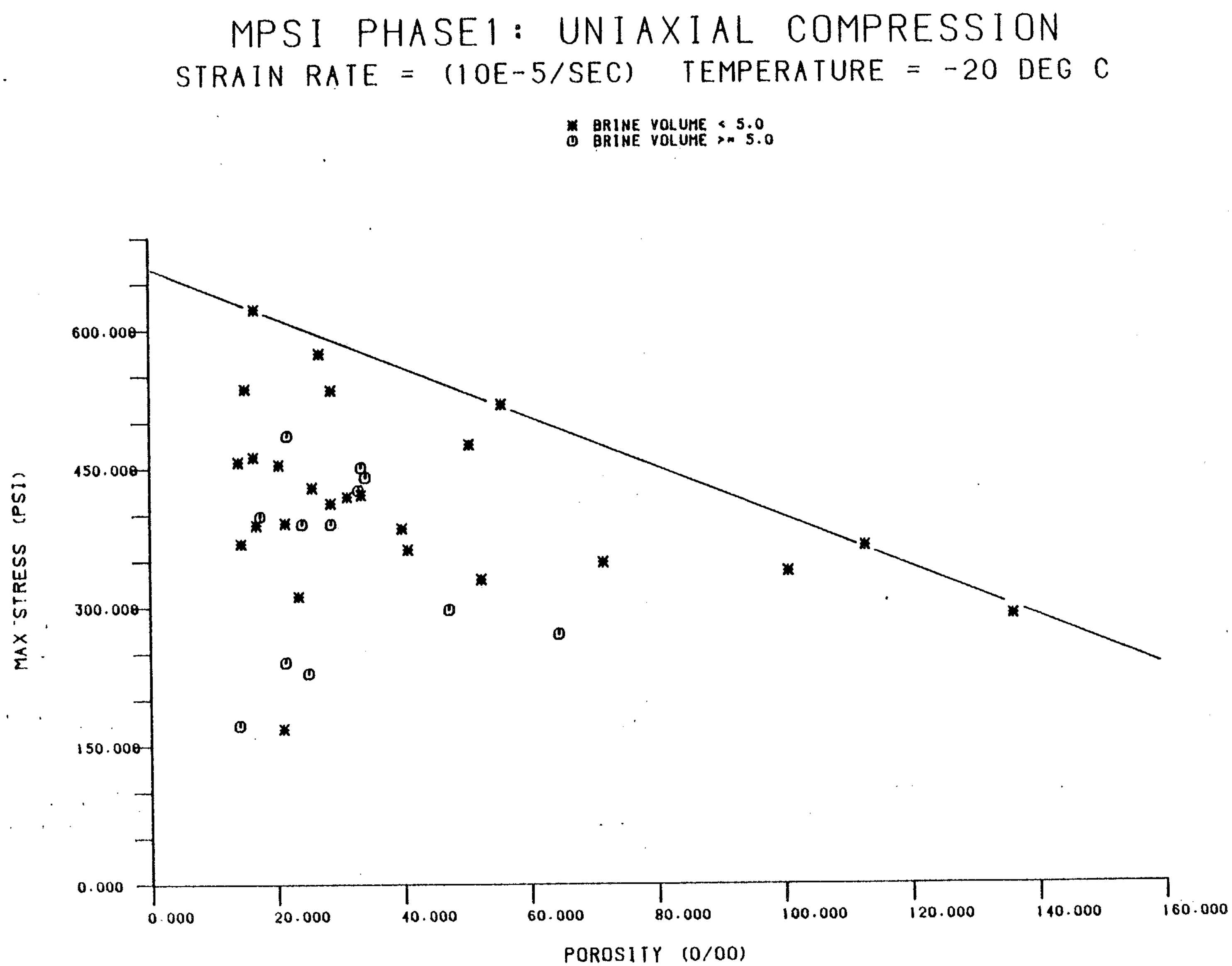

Fig. 34 - Maximum stress as a function of porosity for $\dot{\varepsilon} = 10^{-5}$/sec and $T = -20°C$.

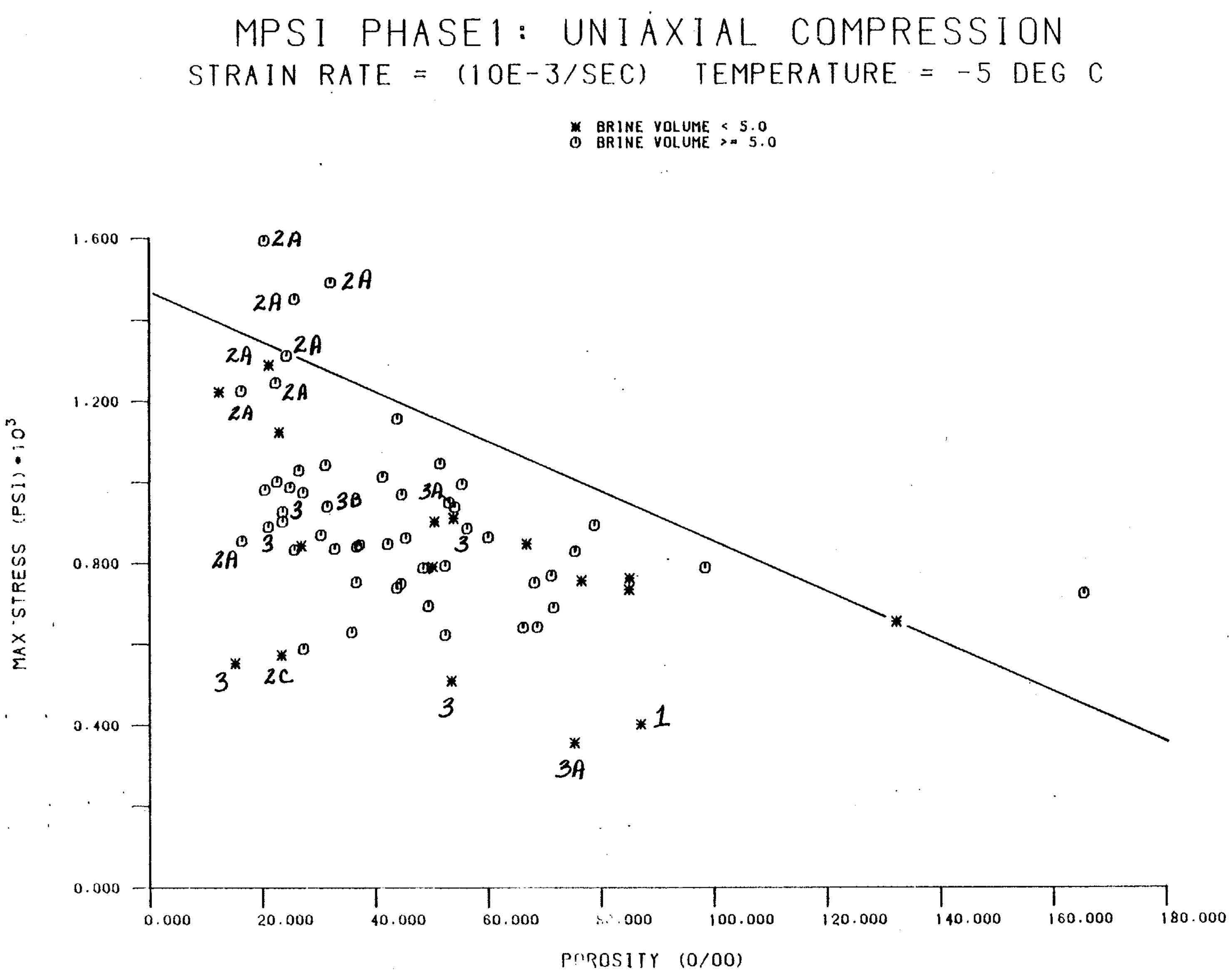

Fig. 35 - Maximum stress as a function of porosity for $\dot{\varepsilon} = 10^{-3}$/sec and T = -5°C.

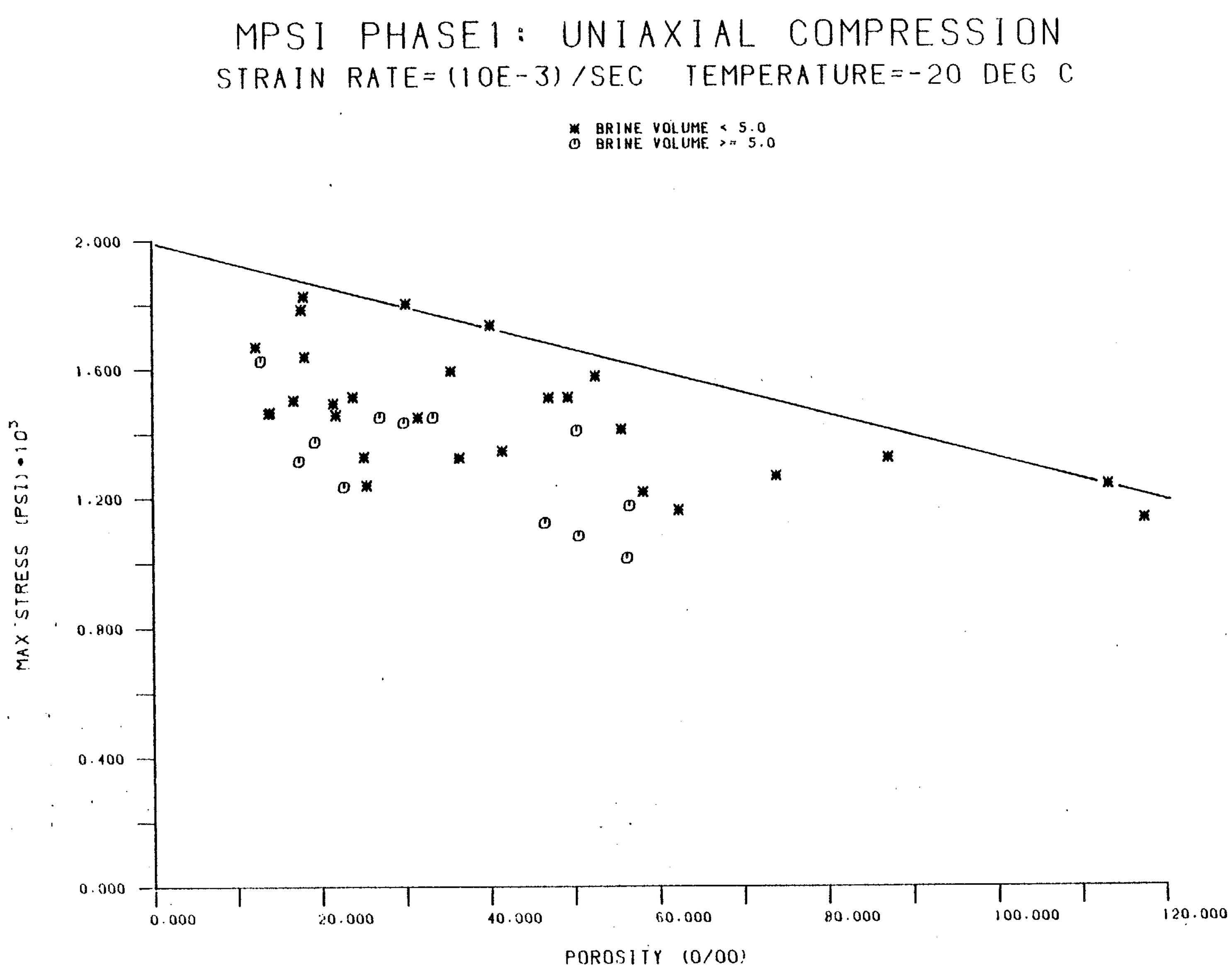

Fig. 36 - Maximum stress as a function of porosity for $\dot{\varepsilon} = 10^{-3}$/sec and T = -20°C.

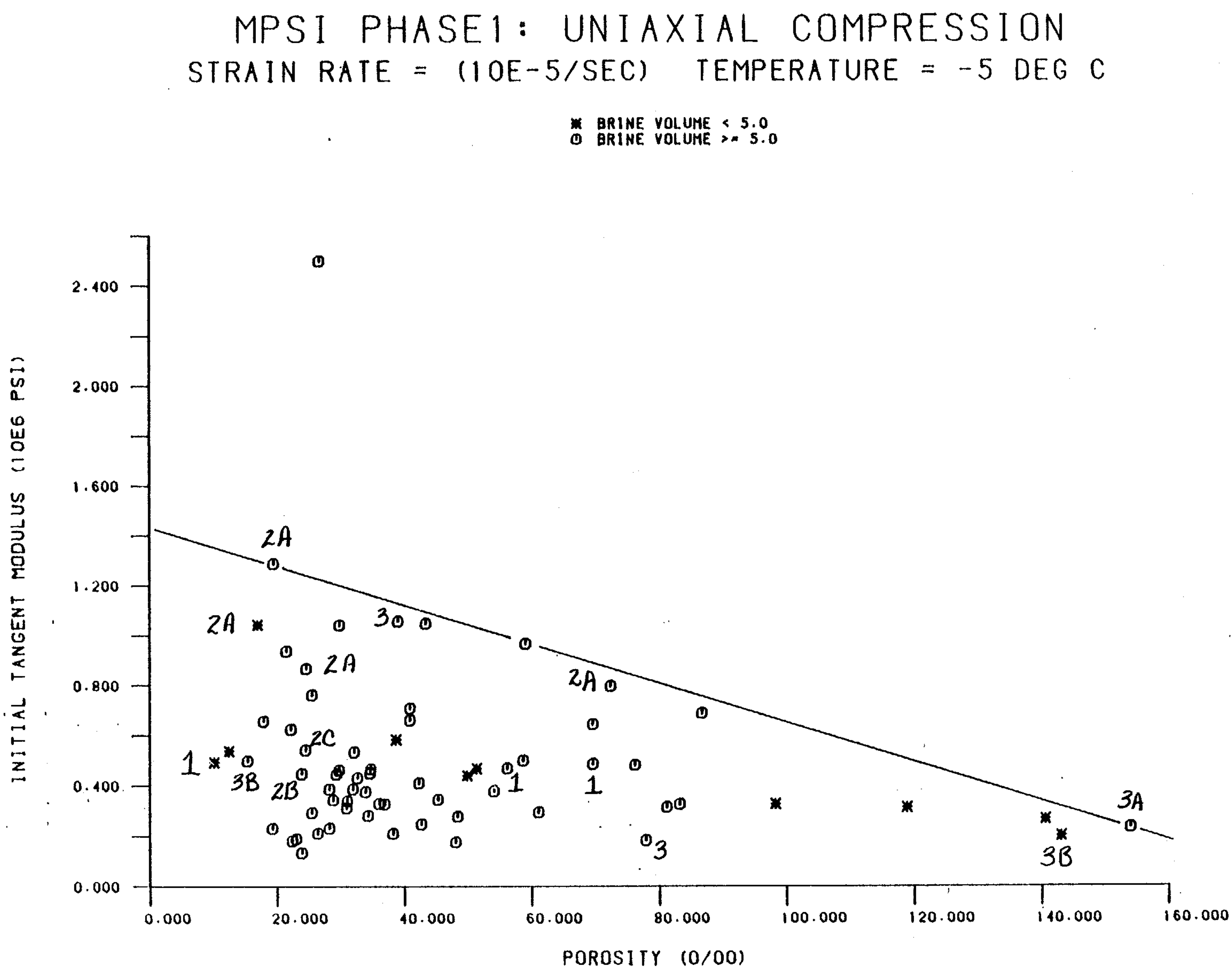

Fig. 37 - Initial tangent modulus as a function of porosity for $\dot{\varepsilon} = 10^{-5}$/sec and T = -5°C.

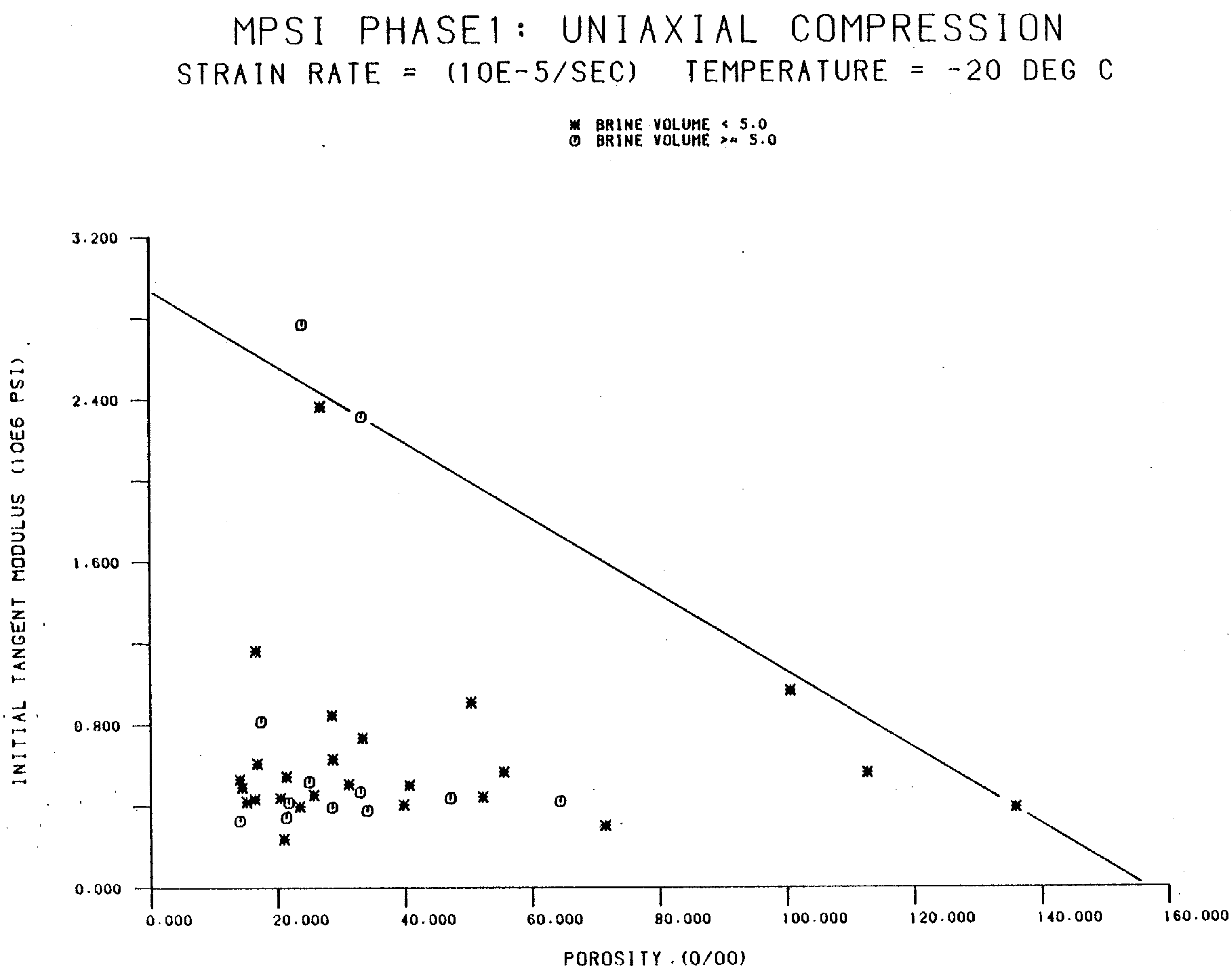

Fig. 38 - Initial tangent modulus as a function of porosity for $\dot{\varepsilon} = 10^{-5}$/sec and T = -20°C.

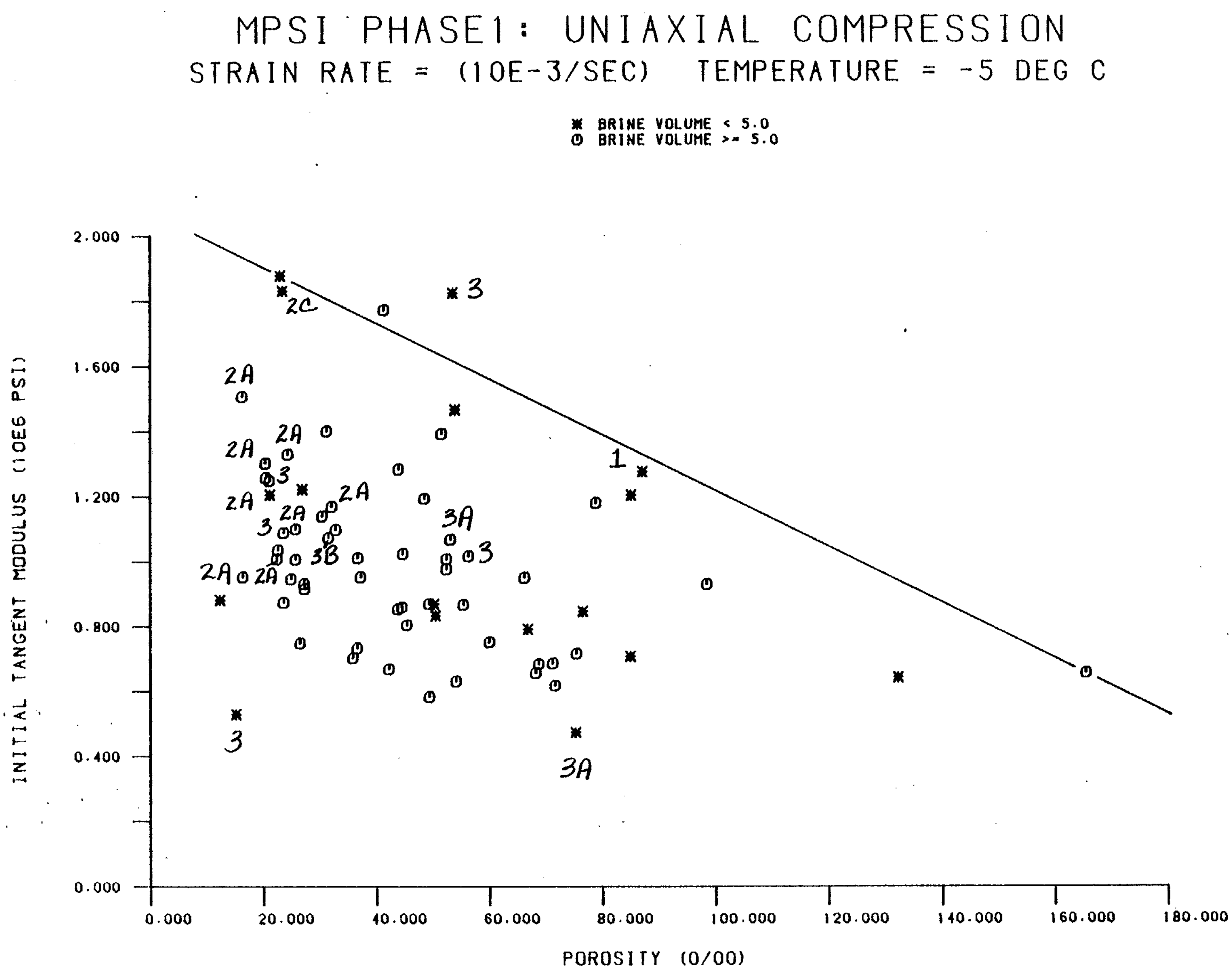

Fig. 39 - Initial tangent modulus as a function of porosity for $\dot{\varepsilon} = 10^{-3}$/sec and T = -5°C.

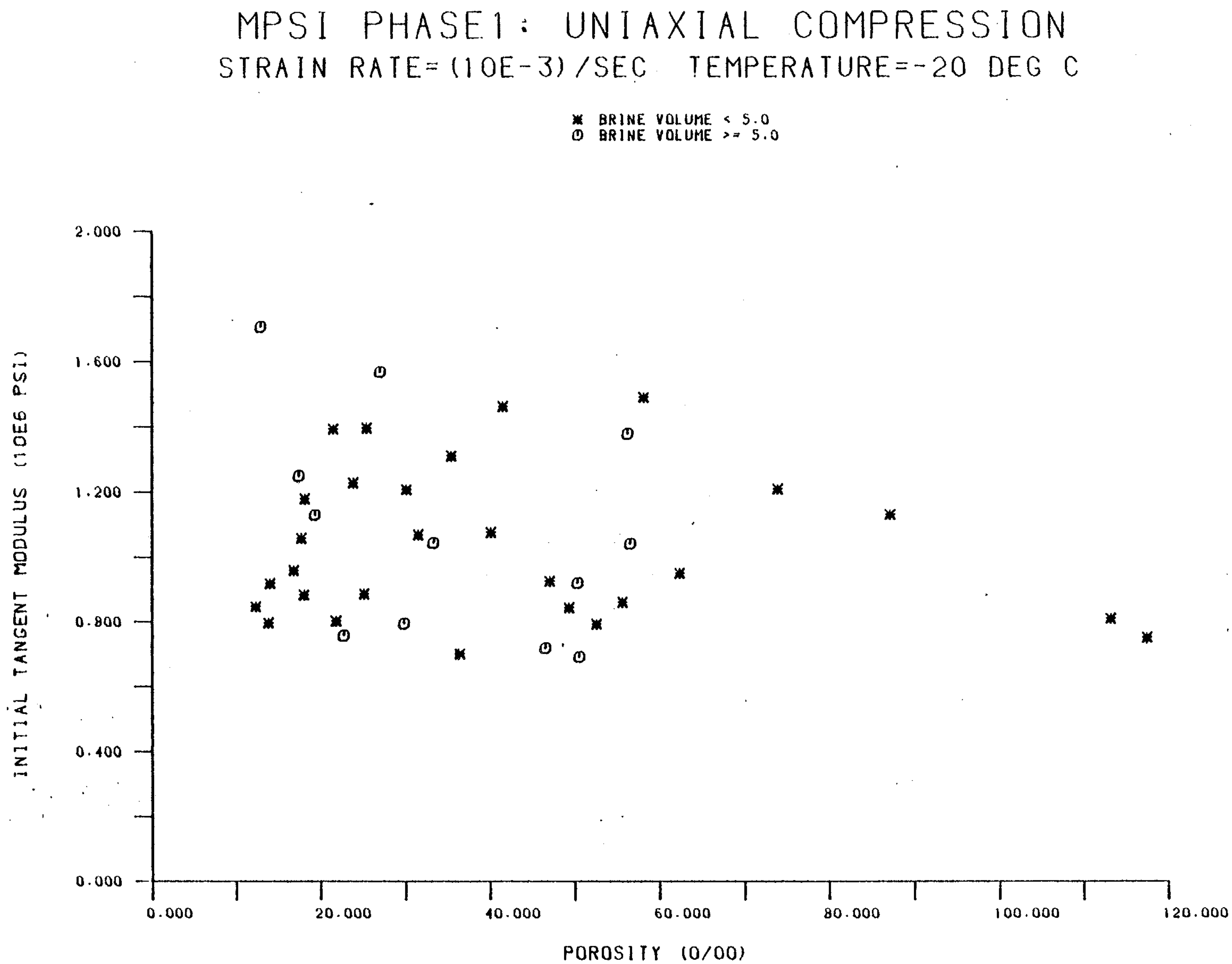

Fig. 40 - Initial tangent modulus as a function of porosity for $\dot{\varepsilon} = 10^{-3}$/sec and T = -20°C.

and 39. In these figures, the columnar ice types (i.e., 2A, 2B, and 2C) appear to be more closely clustered than the granular or mixed ice types (i.e., 1, 3, 3A, and 3B). This is due to the generally low porosity of the columnar samples and the wide range of porosities found in the granular and mixed ice types. The columnar samples, however, do show much scatter in the maximum stress since crystal orientation plays an important role in these samples. The columnar ice types loaded in the hard fail direction (i.e., small angle between the load direction and axis of elongation) generally determine the upper bound on strengths, while the granular, mixed, and columnar loaded in the soft fail direction ice types fall into the intermediate and low strength ranges.

SUMMARY

Current methods of calculating ice loads depend on a knowledge of the mechanical properties of the ice feature being considered. Prior to the completion of MPSI-1 limited data were available describing the uniaxial compressive response of multi-year ridge ice. The results presented here summarize the mechanical properties of approximately 220 uniaxial compression tests conducted at two temperatures and two strain rates in MPSI-1. The effects of temperatures and strain rate on the mechanical properties are investigated by conducting pairwise t-tests on the mean values for the two levels of constant temperature and constant strain rate.

As expected, the t-tests show that the maximum stress and the total dissipated energy increase with increasing strain rate and decreasing temperature. The tangent modulus increases with increasing strain rate but is independent of temperature. The residual stress is independent of strain rate but increases with decreasing temperature. The strain at maximum stress increases with decreasing strain rate, but the t-tests on temperature effects are inconclusive.

An energy based failure criterion was investigated by calculating the energy dissipated to peak strength. The results from the t-tests conducted on this energy quantity show that at all test conditions except for one (i.e., C320), the mean value of the energy dissipated at peak strength is the same. This observation offers some promise for an energy based failure criterion, but further investigations need to be made to understand why the energy dissipated at C320 is different. Even if these investigations prove

fruitless, an energy based failure criterion could possibly be hypothesized on a restricted temperature strain-rate regime where the mean values of the energy dissipated to peak strength are the same.

Improved techniques for calculating ice loads will depend on more than a knowledge of a single mechanical property such as the compressive strength. Numerical modeling techniques, such as the finite element method for example, can take advantage of the entire stress-strain curve to describe the material behavior. Given the large variations observed in the mechanical properties, a means of classifying the stress-strain curves was sought to allow a comparison of different curves at a particular test condition and to investigate the effects of temperature and strain rate on the stress-strain response.

The total energy dissipated (I_T) by an ice sample seems to be a logical choice as a parameter for discussing the stress-strain response since all important mechanical properties contribute to its calculation. Material response is typically described in qualitative terms as being either brittle or ductile. However, this familiar terminology is of no use in connection with I_T unless its spatial distribution in the stress-strain plane is somehow brought into play.

A measure of the spatial distribution of I_T can be derived by decomposing I_T into a rate independent and a rate dependent part. The rate independent component of the total energy dissipated is defined as the flow energy (I_F) and the rate dependent component is defined as the crushing energy (I_C). The ratio, I_C/I_F, can now be used to provide a quantitative measure of ductility or brittleness. An ice sample with a low I_C/I_F value has a flat stress-strain curve and hence represents a ductile response. On the other hand, a high I_C/I_F value indicates a sharp stress-strain curve. Rate independent correlations between stress and energy components can be obtained by pairing the flow energy with the residual stress (σ_R) and the crushing energy with the maximum stress (σ_M). From these correlations, we find the quantity

$$\left(\frac{\sigma_M - \sigma_R}{\sigma_R}\right)$$

is proportional to I_C/I_F and hence provides another measure of brittleness or ductility.

Pairwise t-tests were conducted for the ratio I_C/I_F for the two levels of constant temperature and strain rate. Results show that the mean value of I_C/I_F does not change with temperature but increases with increasing strain rate. Thus, changes in temperature cause a proportional change in the shape of the stress-strain curve. This is due to approximately proportional increases in maximum stress and residual stress with decreasing temperature. Changes in strain rate cause a distortion in the shape of the stress-strain curve as one would expect.

A comparison of the I_C/I_F value within a particular test condition shows large variation of the mechanical response. If the entire stress-strain response is to be incorporated into an improved design methodology, then a method needs to be chosen to somehow suitably average the wide range of responses observed at a particular test condition. Two methods were investigated. The first method is simply a point by point averaging of each curve. The second method is to minimize the least square "error" from the mean of all important mechanical properties. Of the two methods investigated, the second is the easier method to apply and provides a means of choosing a real stress-strain curve which is more faithful to the observed average mechanical properties.

The effects of the physical properties on the mechanical properties were briefly investigated. Similar to other ice types, the maximum stress and tangent modulus of multi-year ridge ice decrease with increasing porosity. The possibility that the samples with low brine volumes form an upper bound on the strength vs porosity and tangent modulus vs porosity plots was also investigated but no such upper bound was found. The limited amount of crystallographic information showed that columnar samples had smaller variations in porosity than other ice types, but still had large variations in strengths due to variations in the orientations of the axis of elongation of the crystal with respect to loading direction. The larger variations in mechanical properties of the mixed and granular ice types are due primarily to large variations in porosity.

RECOMMENDATIONS FOR FUTURE WORK

Although the effects of temperature and strain rate on the uniaxial response of multi-year ridge ice have been investigated, our understanding of the material's behavior is by no means complete. In ice-structure interaction problems, the ice will be subjected to three dimensional states of stress. Consequently, a knowledge of the effects of confining pressure on the mechanical response of multi-year ridge ice is needed. Phase II of the program (MPSI-2) includes approximately 60 conventional triaxial tests which will provide information on the pressure dependence of the mechanical response.

It is expected that a simple linear interpolation of the mechanical properties between the two MPSI-1 test temperatures (i.e., -5°C and -20°C) will be adequate to define the temperature dependence of the properties over that temperature range. However, there are situations such as summer floe impacts and the local contact between a ridge keel and conical structure where the temperature of the ice would be warmer than -5°C. At warm temperatures, the mechanical behavior of ice becomes highly nonlinear, and extrapolation of the MPSI-1 temperature data would probably over-predict ice strengths near the melting point. Clearly, warm temperature strength data are needed. A test program independent of the MPSI program has been initiated to obtain these data.

With the completion of the program to obtain warm temperature strength data, we will have a comprehensive view of the small scale mechanical response of multi-year ridge ice. Emphasis should then be shifted from the laboratory to the field. In particular, investigations need to be made on the internal structure of multi-year ridges. The small scale data show large variations in the mechanical properties which are attributed to the wide variety of ice types found in multi-year ridges. Very little is known about the spatial distribution of these ice types within a ridge. Structural trends observed in a ridge could play an important role in the calculation of ice loads. It was observed, for example, that the keel region of the continuous core sampled in MPSI-1 contained predominantly vertically oriented columnar ice. If this is in general true for all keels, then the design methodology and geometry could be modified to take advantage of this feature.

REFERENCES

1. Cox, G. F. N., Richter-Menge, J. A., Weeks, W. F., Mellor, M., and Bosworth, H. W. (1983), The Mechanical Properties of Multi-Year Sea Ice, Phase I: Test Results, Report 84-9, Cold Regions Res. and Eng. Lab., U.S. Army, Hanover, New Hampshire.

2. Cox, G. F. N., Richter, J. A., Weeks, W. F., and Mellor, M. (1984), A Summary of the Strength and Modulus of Ice Samples from Multi-Year Pressure Ridges, presented at the Third Int. Offshore Mech. and Arctic Symposium, Am. Soc. Mech. Eng., New Orleans, February.

3. Richter, J. A. and Cox, G. F. N. (1984), A Preliminary Examination of the Effect of Structure on the Compressive Strength of Ice Samples from Multi-Year Pressure Ridges, presented at the Third Int. Offshore Mech. and Arctic Symposium, Am. Soc. Mech. Eng., New Orleans, February.

4. Weeks, W. F. (1984), The Variation of Ice Strength Within and Between Multi-Year Pressure Ridges in the Beaufort Sea, presented at the Third Int. Offshore Mech. and Arctic Symposium, Am. Soc. Mech. Eng., New Orleans, February.

5. Mellor, M., Cox, G. F. N., and Bosworth, H. W. (1984), The Mechanical Properties of Multi-Year Sea Ice, Phase I: Techniques for Measuring the Mechanical Properties of Ice, Report 84-8, Cold Regions Res. and Eng. Lab., U.S. Army, Hanover, New Hampshire.

6. Cox, G. F. N. and Weeks, W. F. (1982), Equations for Determining the Gas and Brine Volumes in Sea Ice Samples, Report 82-30, Cold Regions Res. and Eng. Lab., U.S. Army, Hanover, New Hampshire.

7. Dorris, J. F. (1985), Classification of Failure Modes for Unconfined Compression Tests of Multi-Year Ridge Ice, Technical Information Record BRC-1285, Shell Development Bellaire Research Center, Houston.

8. Mellor, M. (1983), Mechanical Behavior of Sea Ice, Mon. 83-1, Cold Regions Res. and Eng. Lab., U.S. Army, Hanover, New Hampshire.

9. Weeks, W. F. (1982), The Growth, Structure, and Properties of Sea Ice, Mon. 82-1, Cold Regions Res. and Eng. Lab., U.S. Army, Hanover, New Hampshire.

10. Cherepanov, N. V. (1974), Classification of Ice of Natural Water Bodies, Proc. Int. Conf. Eng. Ocean Environ., Ocean 74, Inst. Electr. Electron. Eng., Halifax, Nova Scotia.

11. Michel, B. (1978), Ice Mechanics, Les Presses de l'Universite' Laval, Quebec, Canada.

12. IMSL Reference Manual, Edition 7 (1979), International Mathematical and Statistical Libraries, Inc., Houston.

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3/85

THE UNIAXIAL MECHANICAL RESPONSE OF MULTI-RIDGE ICE

VOLUME III
APPENDIX B - CUBIC SPLINES FORCE-TIME HISTORIES

BY

J. F. DORRIS AND J. S. AUSTIN

TECHNICAL PROGRESS REPORT

BRC 45-85
OCTOBER 1985

Project No. 327-27802.34
Mechanical Properties of Sea Ice

SHARED - Under the Research Agreement between SIRM, and Shell Oil Company dated January 1, 1960, as amended.

Reviewed by: E.G. Ward
E.N. Earle
Participant: C.A. Gutierrez
Released by: J.H. Lybarger
Reference: Based on work through December 1983.

Appendix B

CUBIC SPLINES FOR FORCE-TIME HISTORIES

Appendix B

SPLINE COEFFICIENTS FOR FORCE-TIME HISTORIES

THE UNIAXIAL MECHANICAL RESPONSE OF MULTI-RIDGE ICE

VOLUME II
APPENDIX A - PROCEDURE FOR SMOOTHING MPSI STRESS STRAIN CURVES

BY

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LIST OF ILLUSTRATIONS

LIST OF TABLES

Appendix A

PROCEDURE FOR SMOOTHING MPSI STRESS STRAIN CURVES

Appendix A

PROCEDURE FOR SMOOTHING MPSI STRESS-STRAIN CURVES

INTRODUCTION

In Phase I of the Mechanical Properties of Sea Ice (MPSI) program, approximately 200 uniaxial constant strain rate compression tests were conducted. These tests were recorded on an FM magnetic tape recorder. It was necessary to digitize the analog magnetic tapes in order to employ a computer analysis of the data. After digitization, the data were processed further by fitting cubic splines to the digital data from each test. This step serves three purposes:

1. Cubic splines provide a more efficient means of storing the data,
2. Any noise in the data is filtered out, and
3. Application of constitutive models to ice requires an analytical description of the stress-strain curve.

The following account describes the procedures employed in obtaining the smooth stress-strain curves from the digitized data.

CUBIC SPLINES

The cubic splines for each test are found by employing the IMSL[12] subroutine ICSVKU. This subroutine requires that the range of the independent variable, t, be divided into (k-1) intervals by selecting k knots, t_i, $i = 1, 2, \ldots, k$. The subroutine then calculates a cubic spline S_i for each interval. Taken together, the splines form a (k-1) branched composite function, F(t), which is continuous and has continuous first and second derivatives at each intermediate knot. The cubic splines are chosen so that the composite function minimizes the least squares error of the approximation to the digitized data.

Each spline, S_i, is referred to a local coordinate system, $(\xi_i, S_i(\xi_i))$ whose origin is located at the point $(t_i, 0)$. To evaluate the composite function at the point $t = \hat{t}$, one must first find the knot interval, I_i: $t_i \leq \hat{t} \leq t_{i+1}$, in which the point lies. Once this interval is found, the function is evaluated by the equation,

$$S_i(\hat{\xi}_i) = \left((C_{i3}\hat{\xi}_i + C_{i2})\,\hat{\xi} + C_{i1}\right)\hat{\xi}_i + y_i, \tag{1}$$

where

$$\hat{\xi}_i = \hat{t} - t_i, \; 0 \le \hat{\xi}_i \le t_{i+1} - t_i \quad .$$

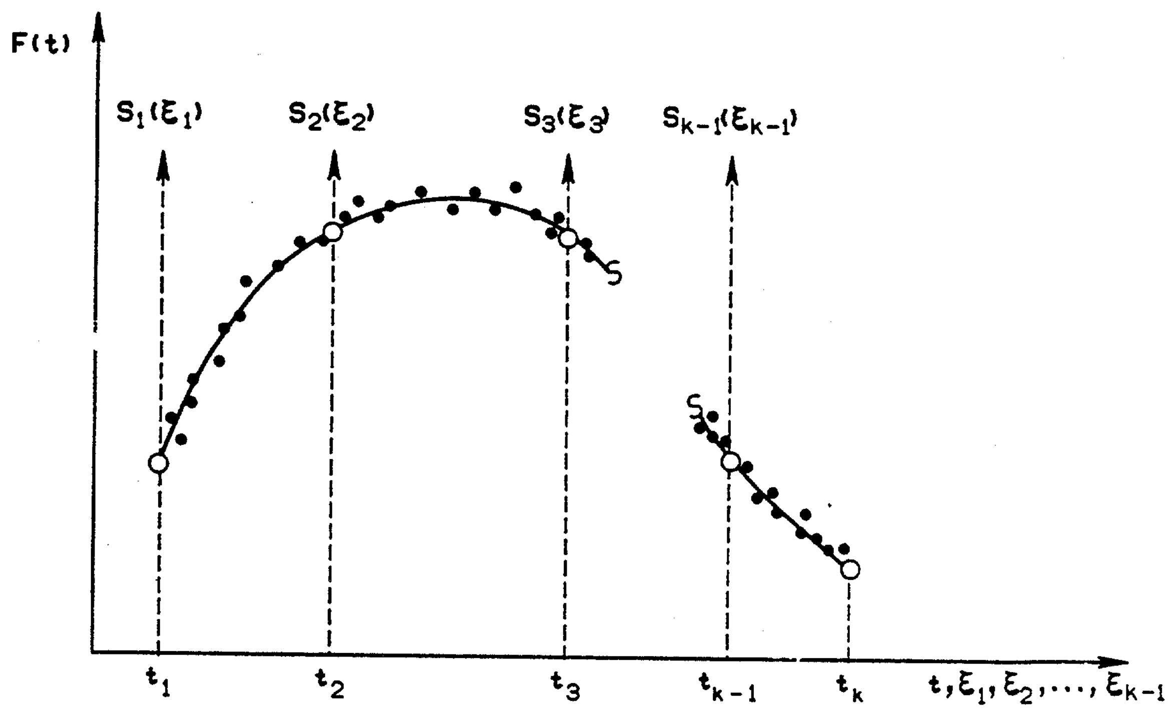
Here C_{i3}, C_{i2}, and C_{i1} are the cubic, quadratic, and linear coefficients, respectively, of the local independent variable, ξ_i. The quantity, y_i, denotes the initial value of the spline in the local coordinate system. These quantities are returned by the subroutine and represent the best fit of the data on the interval, $t_i \le t \le t_{i+1}$. The $(k-1) \times 3$ matrix C_{ij}, the $(k-1)$ dimensional vector y_i, and the k dimensional vector t_i will completely specify the composite function, $F(t)$. These quantities are tabulated in data files for each test. A schematic diagram of the composite function and cubic splines is found in Figure A-1.

The successful use of splines to approximate a data set is dependent on the choice of knots. The subroutine ICSVKU is a variable knot routine which optimizes the knot locations after an initial guess is made for the knots. The IMSL library package also contains several subroutines which evaluate the splines, take first and second derivatives, and integrate. However, it is not necessary to have access to the IMSL library package to perform these calculations, since it is an easy task to program Equation (1) if given the quantities C_{ij}, y_i, and t_i.

TEST MEASUREMENTS

In Phase I, the uniaxial compression tests were conducted at strain rates, $\dot{\varepsilon}$, of 10^{-5}/sec and 10^{-3}/sec, and temperatures, T, of -5°C and -20°C. Each test sample was loaded at a constant strain rate until either the sample failed or the strain reached 5%. The shape of the stress-strain curve is highly dependent on strain rate and much less dependent on temperature. Consequently, for the purpose of curve fitting, we will only consider the two strain rates to be the test conditions. All observations or conclusions regarding tests at a given strain rate will apply to both temperatures. In the following, two tests are chosen to be typical examples of the results from each of the two strain rates. Test number R5A-165/191 will represent the 10^{-5}/sec tests and test number R4B-299/325 will represent the 10^{-3}/sec tests.

In each test, a load cell recorded the axial force as a function of time. The axial displacement was also recorded as a function of time with an extensometer and two DCDTs. The extensometer recorded displacements over the



$$F(t) = \left\{ \begin{array}{ll} S_1(\xi_1) & , \; 0 \le \xi_1 \le t_2 - t_1 \\ S_2(\xi_2) & , \; 0 \le \xi_2 \le t_3 - t_2 \\ S_3(\xi_3) & , \; 0 \le \xi_3 \le t_4 - t_3 \\ \vdots & \qquad\qquad \vdots \\ S_{k-1}(\xi_{k-1}) & , \; 0 \le \xi_{k-1} \le t_k - t_{k-1} \end{array} \right\} t_1 \le t \le t_k$$

WHERE,

$$S_i(\xi_i) = \left\{ \left[C(i,3)\,\xi_i + C(i,2) \right] \xi_i + C(i,1) \right\} \xi_i + y_i$$

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Fig. A-1 - Typical spline fit to experimental data.

full sample length (10 in.) and was used as the feedback control on the closed loop testing machine. The two DCDTs were mounted on the ice sample 180° apart with a 5 1/2" gage length. The calibrated output from the load cell is converted to stress by dividing by the original cross-sectional area of the sample, and the calibrated output from the axial displacement transducers is converted to strain by dividing by the appropriate gage length.

In Figures A-2 and A-3, the strain recorded from each axial displacement transducer is recorded as a function of time for each strain rate. At the beginning of each test, there is close agreement between all three transducers, but there is a point at which the output of the two DCDTs begins to diverge from the extensometer. This point is usually just prior to the peak force. Ideally for a constant strain rate test, the DCDTs should produce linear measurements similar to the extensometer throughout the test. However, at times corresponding to the peak force, the ice begins to undergo nonhomogeneous deformations characterized by highly localized bulging and fracturing. Since the DCDTs are attached directly to the ice, their nonlinear measurements are a direct result of the nonhomogeneous deformations. For this reason the measurements from the DCDTs should not be considered dependable beyond the initial portion of the test. The extensometer, on the other hand, measures the relative displacement of the endcaps, and its measurements should be interpreted as the average displacement over the sample length. Since we are interested in constant strain rate up to 5% strain, only the extensometer will be used to measure axial displacement.

The complete time histories for the load and strain measured from the extensometer as shown in Figures A-4 and A-5 for each strain rate. The force histories for each strain rate are plotted on the same coordinate axes in Figure A-6 to illustrate the change in shape with strain rate. As will be seen later, the differences in shape will require slightly different fitting techniques for each strain rate.

FITTING PROCEDURES FOR FORCE-TIME CURVES

When conducting an experiment, the experimentalist attempts to create an idealized situation to obtain measurements for use in a theoretical model or hypothesis. But, because of experimental limitations, it is usually impossible to create these ideal situations, causing some discrepancies between experiment and theory which should be accounted for in the data analysis.

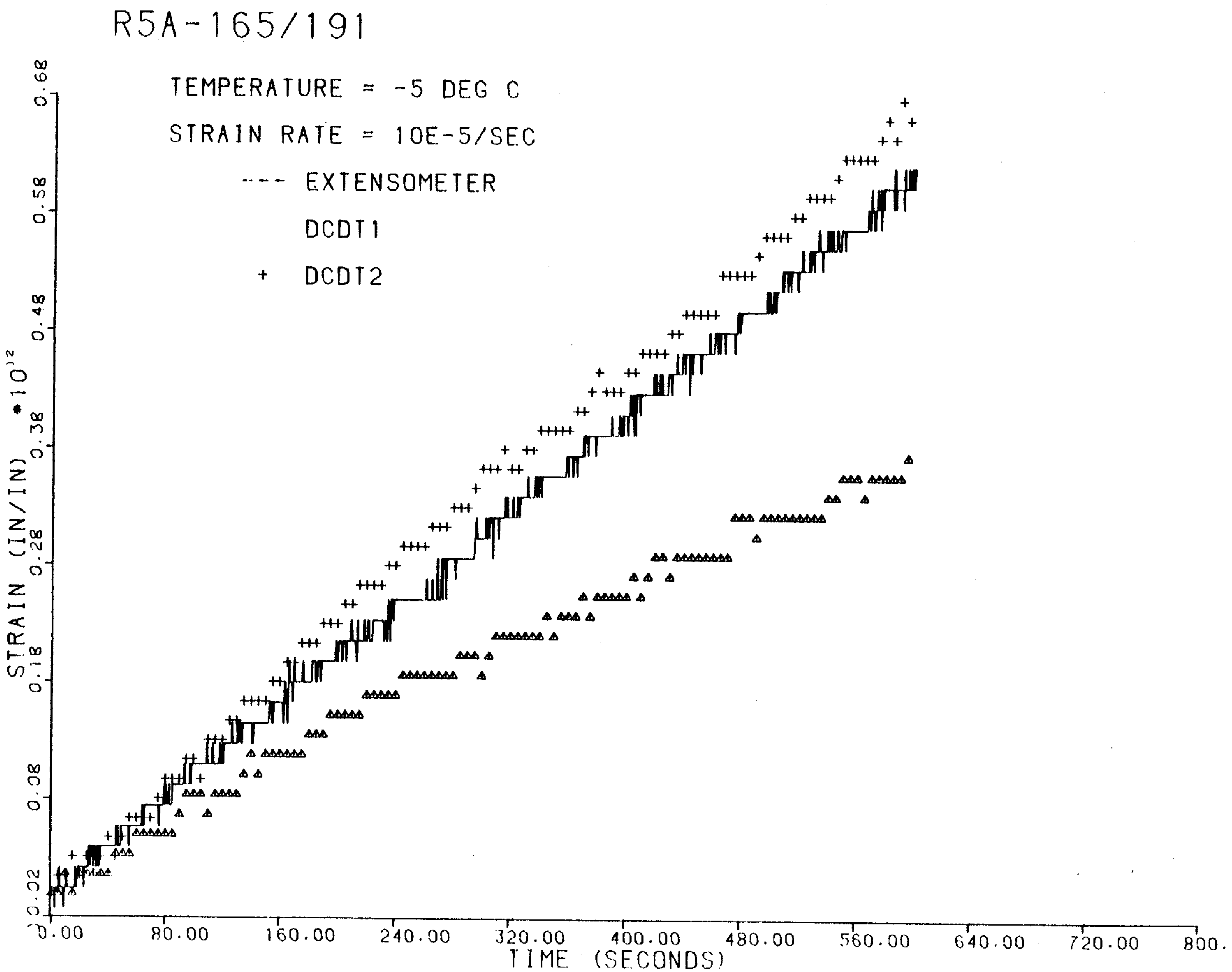

Fig. A-2 - Enlarged view near the origin of the strain measured by the extensometer and the two DCDTs for a $\dot{\varepsilon} = 10^{-5}$/sec test.

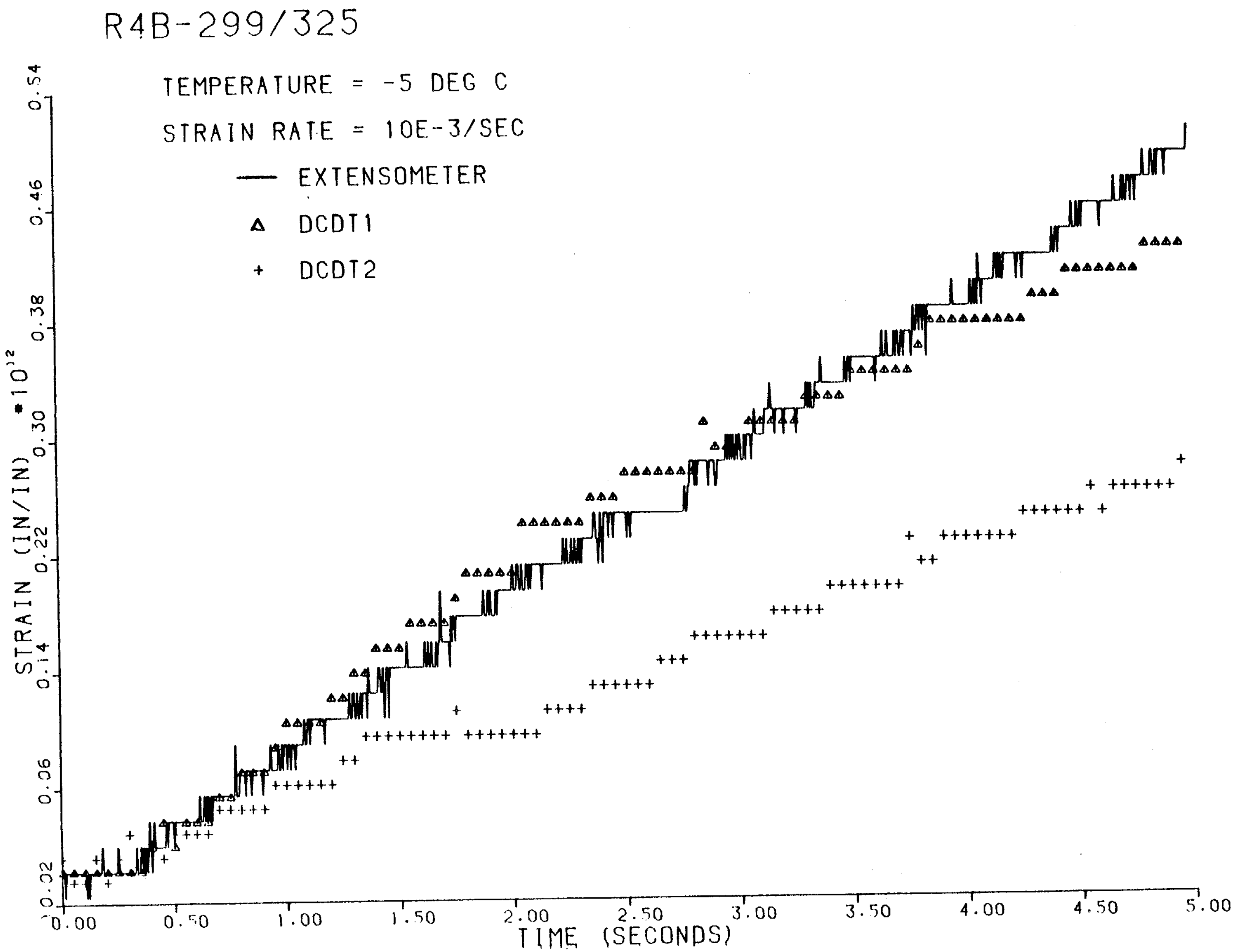

Fig. A-3 - Enlarged view near the origin of the strain measured by the extensometer and the two DCDTs for a $\dot{\varepsilon} = 10^{-3}$/sec test.

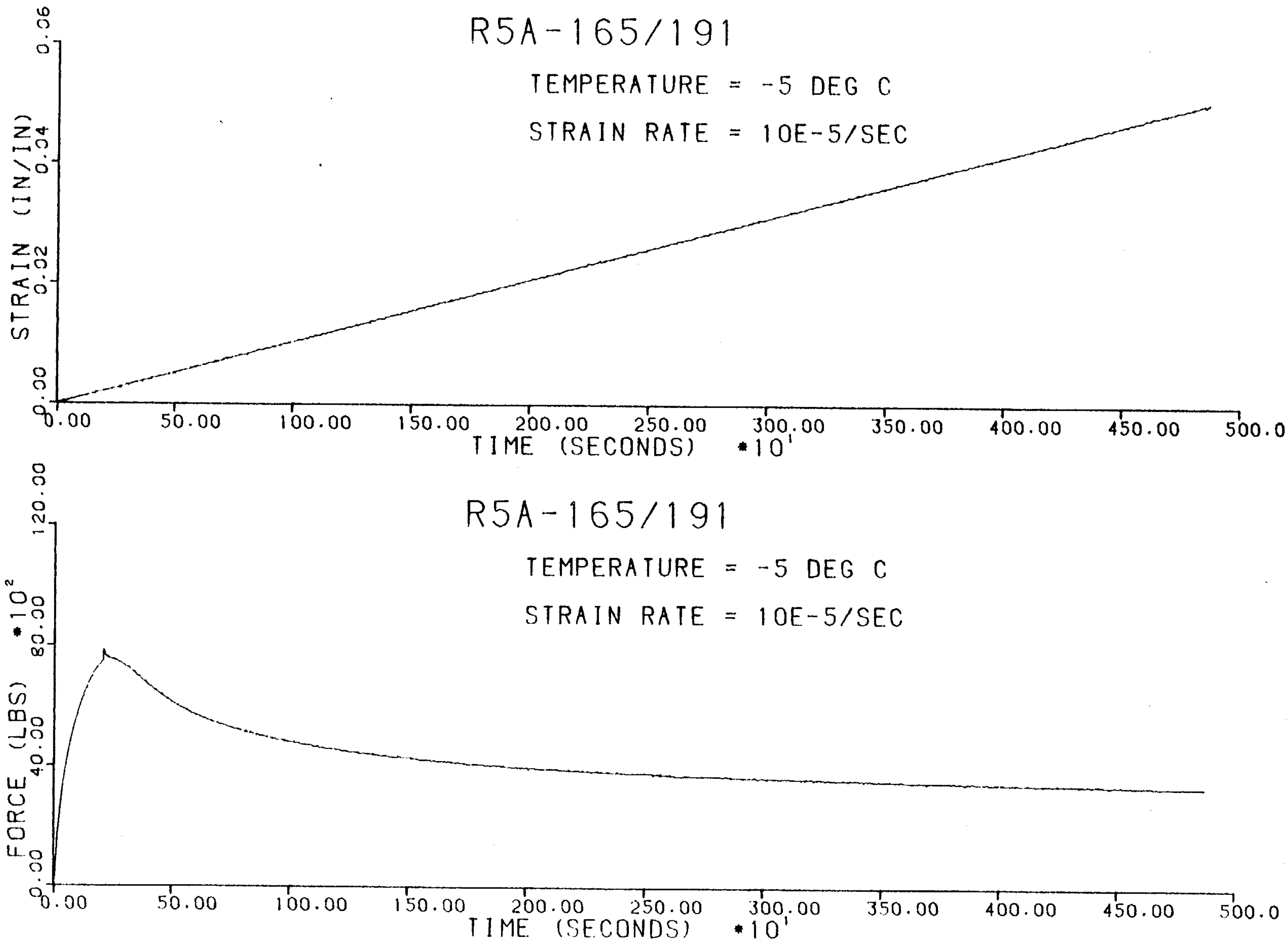

Fig. A-4 - Measured strain and force histories for a $\dot{\varepsilon} = 10^{-5}$/sec test.

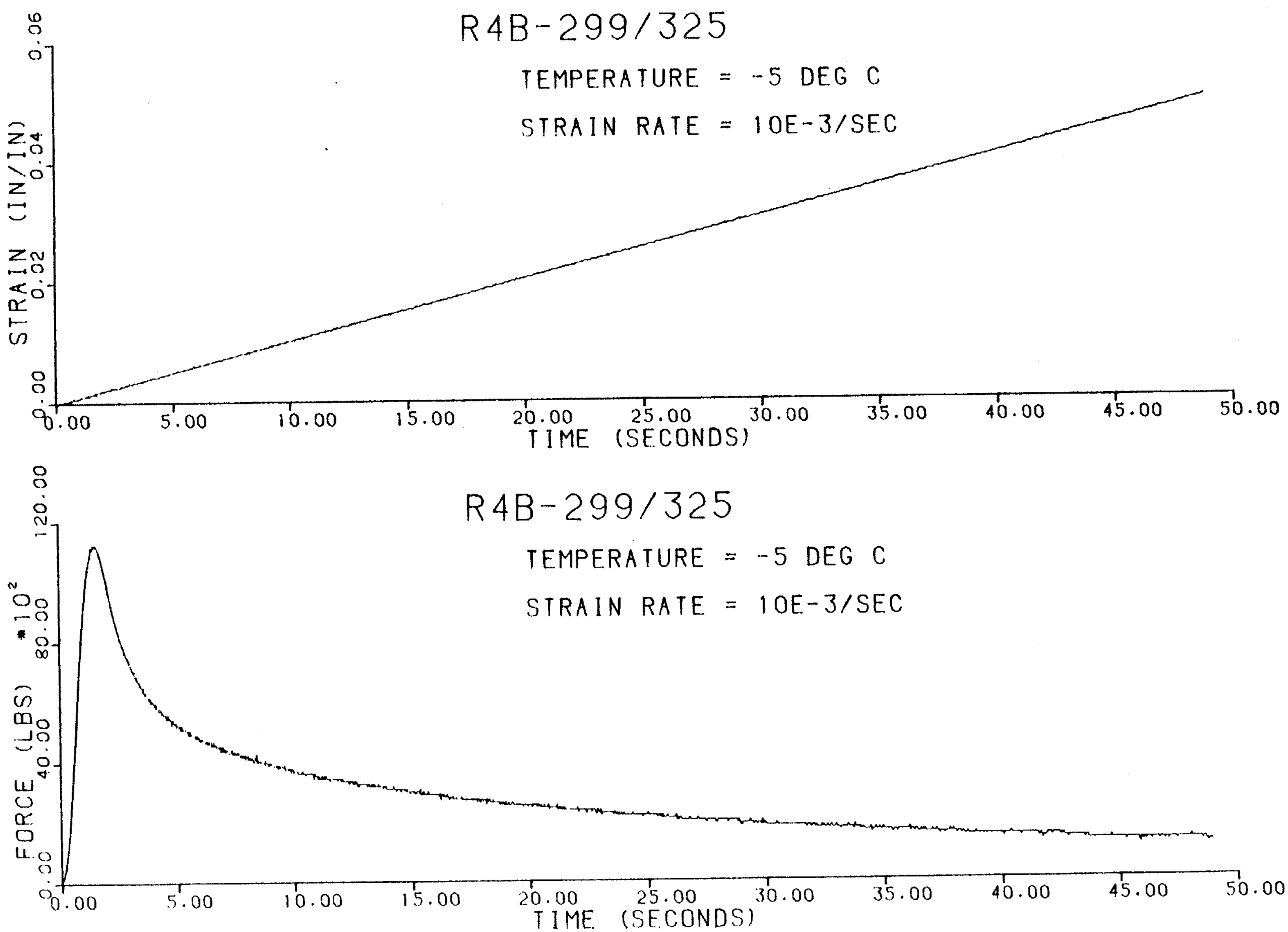

Fig. A-5 - Measured strain and force histories for a $\dot{\varepsilon} = 10^{-3}$/sec test.

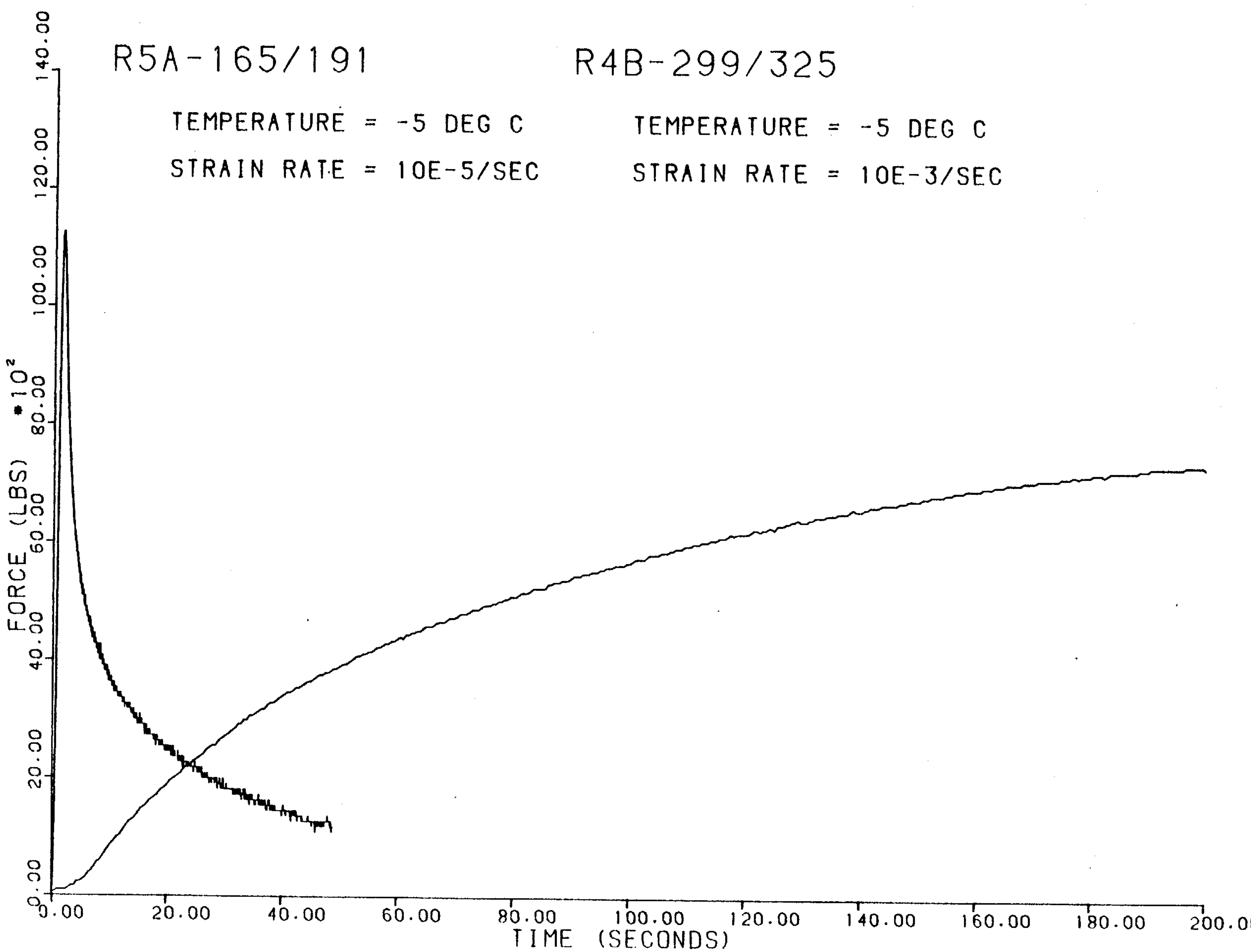

Fig. A-6 - Measured force histories for a $\dot{\varepsilon} = 10^{-5}$/sec and $\dot{\varepsilon} = 10^{-3}$/sec test on the same coordinate axes.

To illustrate some of the discrepancies arising from the uniaxial compression tests, consider Figures A-7 to A-10 which show enlarged views of the force and strain measurements near the beginning of each test. In Figures A-7 and A-9, the force increases from zero at time, t = 0, as expected, whereas in Figures A-8 and A-10, the axial displacement does not increase from zero until approximately t = 8 sec for the 10^{-5}/sec tests and t = 0.3 sec for the 10^{-3}/sec tests. This apparent discrepancy in the starting time is due to the finite amount of time required for the machine to overcome the initial condition of being at rest and then reach a steady state condition of constant strain rate. The resolution of the transducers and digitizing hardware also prohibits the measurement of very small strains near t = 0. Figures A-7 and A-9 also show the initial curvature (i.e., the second derivative) of the force-time curves to be positive. This initial positive curvature is partly due to the initially nonconstant strain rate and is partly due to the elastic closure of voids and microcracks which acts to stiffen the material response. Because of the positive initial curvature, the maximum slope would occur sometime after the beginning of the test. This contradicts a fundamental assumption of constitutive theories (e.g., elasto-plasticity, viscoelasticity, etc.) commonly used to describe materials having nonlinear stress-strain curves. These theories assume the maximum slope occurs at the beginning of the test and represents the initial elastic response of the material.

With the previous problems in mind, procedures were developed to produce force-time curves which conform to the following guidelines:

1. Obtain accurate measurement of the mechanical properties. The properties of major interest from the stress-strain curves are the peak stress, the maximum slope, and the residual stress.

2. Develop a systematic method to resolve the apparent discrepancy in the start time of the force and axial displacement measurements.

3. Generate stress-strain curves whose initial slope is the maximum slope. In doing this, we are in effect editing out the initial positive curvature in the data. Although it is recognized that this feature is an intrinsic material property in geological materials such as rock, we do not feel that the exclusion of this feature will have an effect on ice loads calculated from these edited stress-strain curves.

The subroutine ICSVKU finds cubic splines which minimize the least squares error of the entire curve. This, however, does not guarantee a good

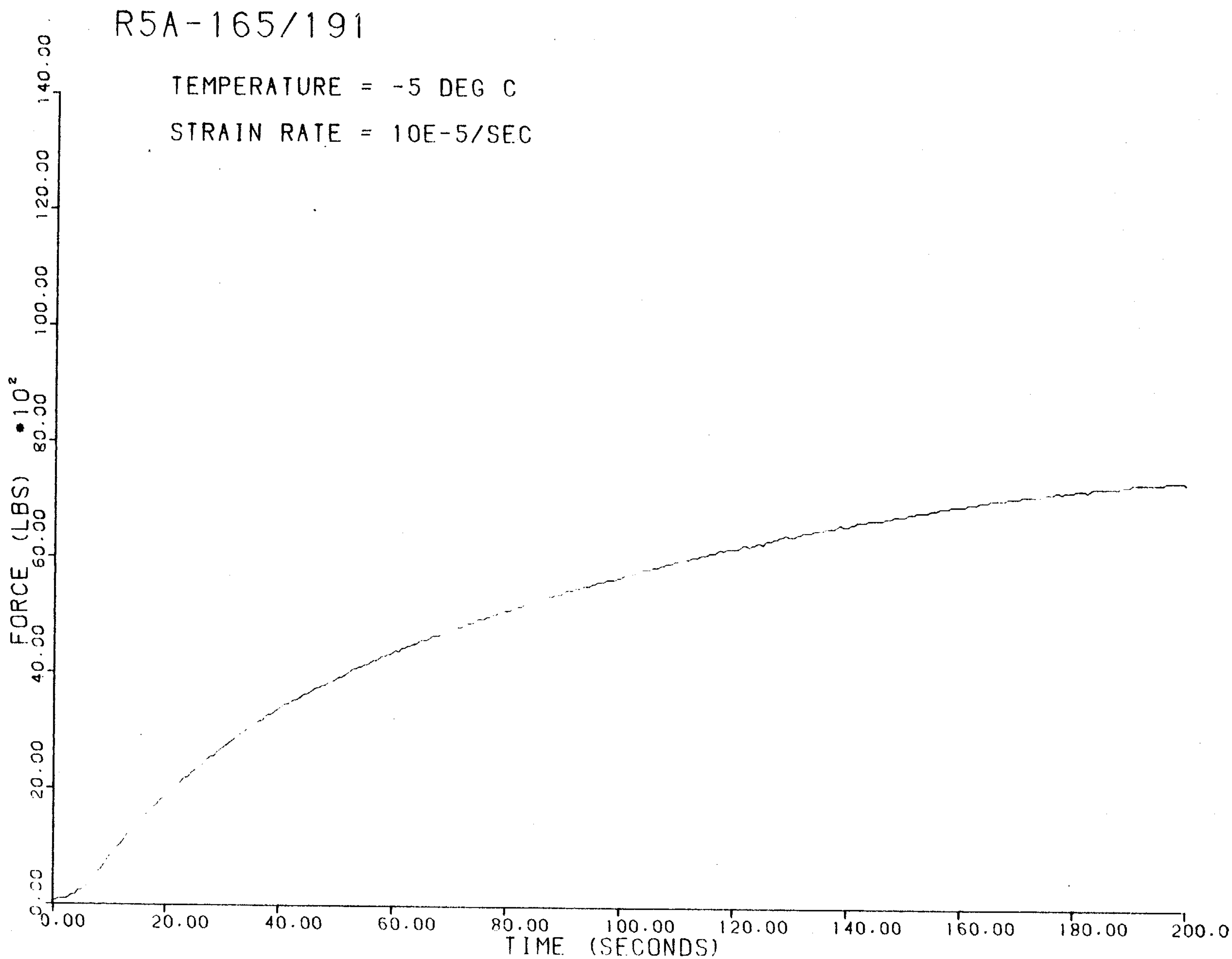

Fig. A-7 - Enlarged view near the origin of the force history for a $\dot{\varepsilon} = 10^{-5}$/sec test.

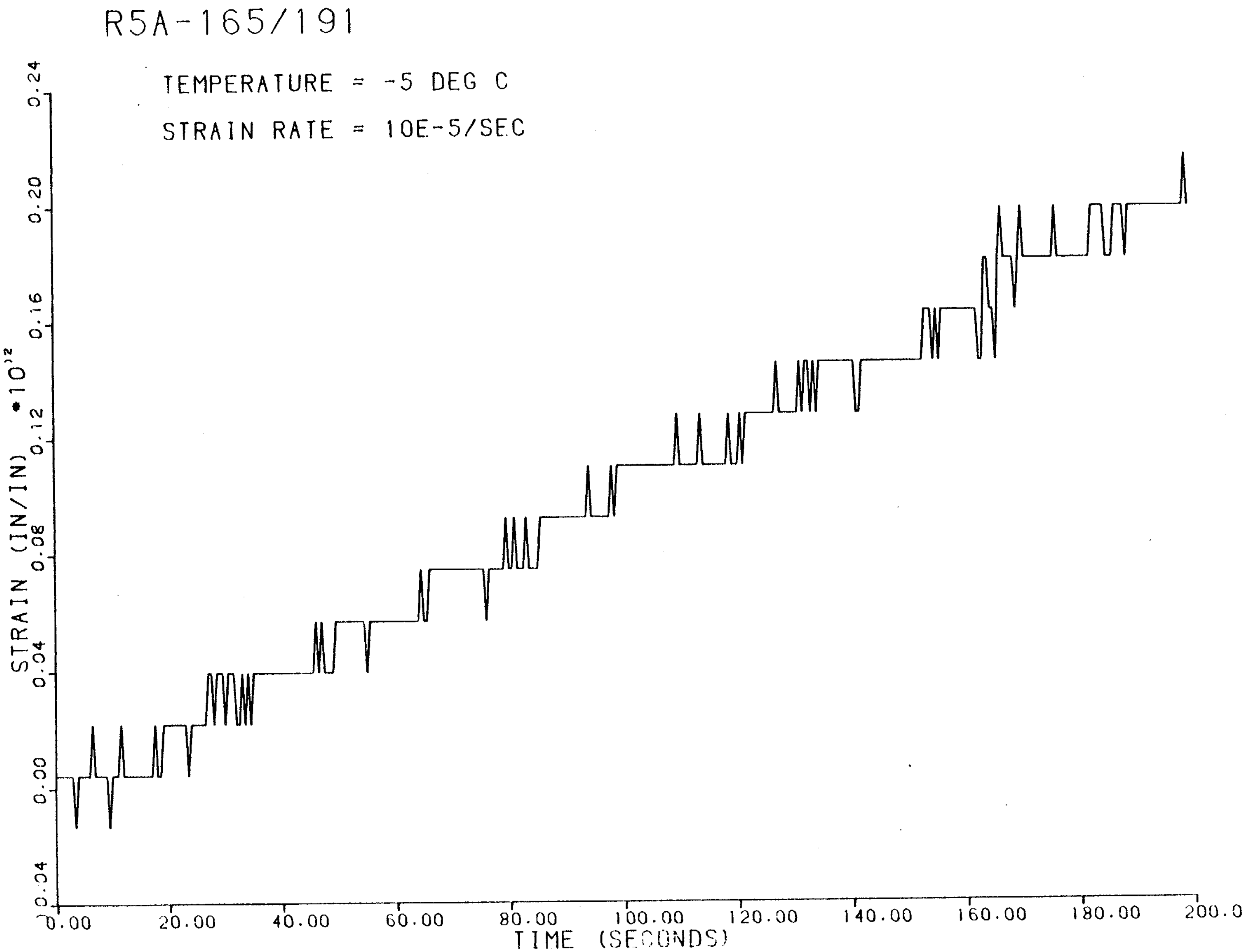

Fig. A-8 - Enlarged view near the origin of the strain history for a $\dot{\varepsilon} = 10^{-5}$/sec test.

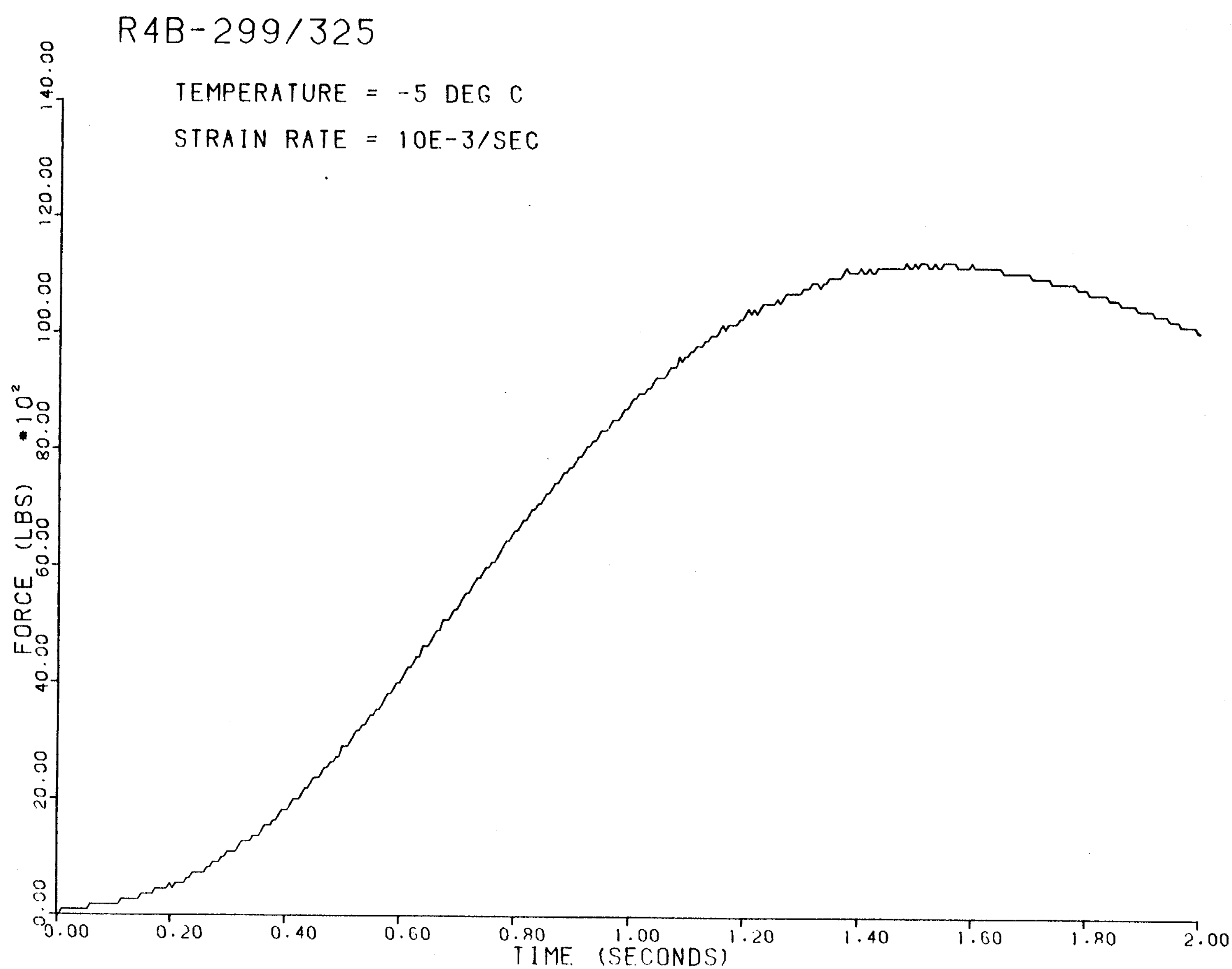

Fig. A-9 - Enlarged view near the origin of the force history for a $\dot{\varepsilon} = 10^{-3}$/sec test.

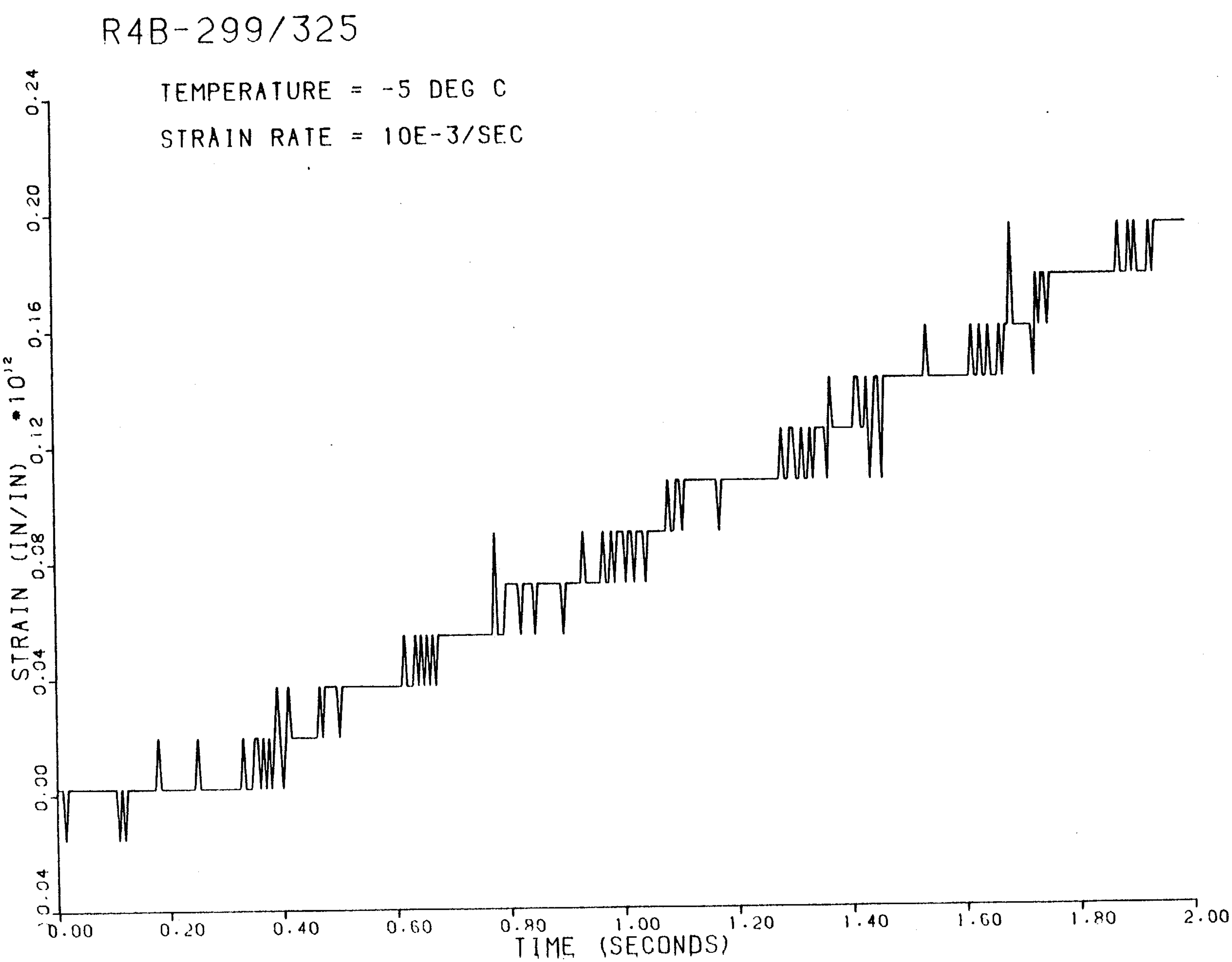

Fig. A-10 - Enlarged view near the origin of the strain history for a $\dot{\varepsilon} = 10^{-3}$/sec test.

local fit. When applying the subroutine to the entire data set of digitized points, good fits are consistently obtained for the points beyond the peak force and poor fits are found for the points up to and around the peak force. The poor fit at the beginning is a result of the subroutine's preference to fit the smooth portion of the curve beyond the peak force rather than the initial portion where the slope changes rapidly from zero at $t = 0$, reaches a maximum, and goes back to zero at the peak. It is by far easier to minimize the global least squares error by finding a good fit in the smooth post peak area where a majority of the points are located rather than fit well the few points near the origin. Attempts at improving the initial fit by adding more knots near the origin or weighing the initial part with more points failed to achieve consistent results.

To insure an accurate curve fit for the beginning of the force-time data set and hence an accurate measurement of the maximum slope, a primary smoothing is made for the initial part of the data only. This is done by creating a subset of points from the entire data set for each strain rate. For the 10^{-5}/sec strain rate, all points for the first 40 sec comprise the subset for primary smoothing. The subset for the 10^{-3}/sec tests consists of all points to the peak minus the first and last few points to eliminate the portions of the subset which would have zero slopes. The resulting subsets for each strain rate then form a smooth monotonically increasing data function which can be accurately fitted with splines. The subset for each strain rate is then divided into four intervals by selecting five equally spaced knots. Cubic splines are then found for each interval, and the maximum slope is found by calculating the slope at the inflection point. Figures A-11 and A-12 show the data points in each subset, the fitted curve, and the tangent at the point of inflection for the primary smoothing.

A secondary smoothing is then made by creating another data subset for each strain rate consisting of all points to the right of the inflection point. The first few points of the subset are then deleted to insure that the initial slope of the secondary smoothing is less than the previously calculated maximum slope. The 10^{-5}/sec data subset is divided into ten intervals, and the 10^{-3}/sec data set is divided into nine intervals. Cubic splines are then found for each interval. These splines are then considered final for that portion of the force-time curve.

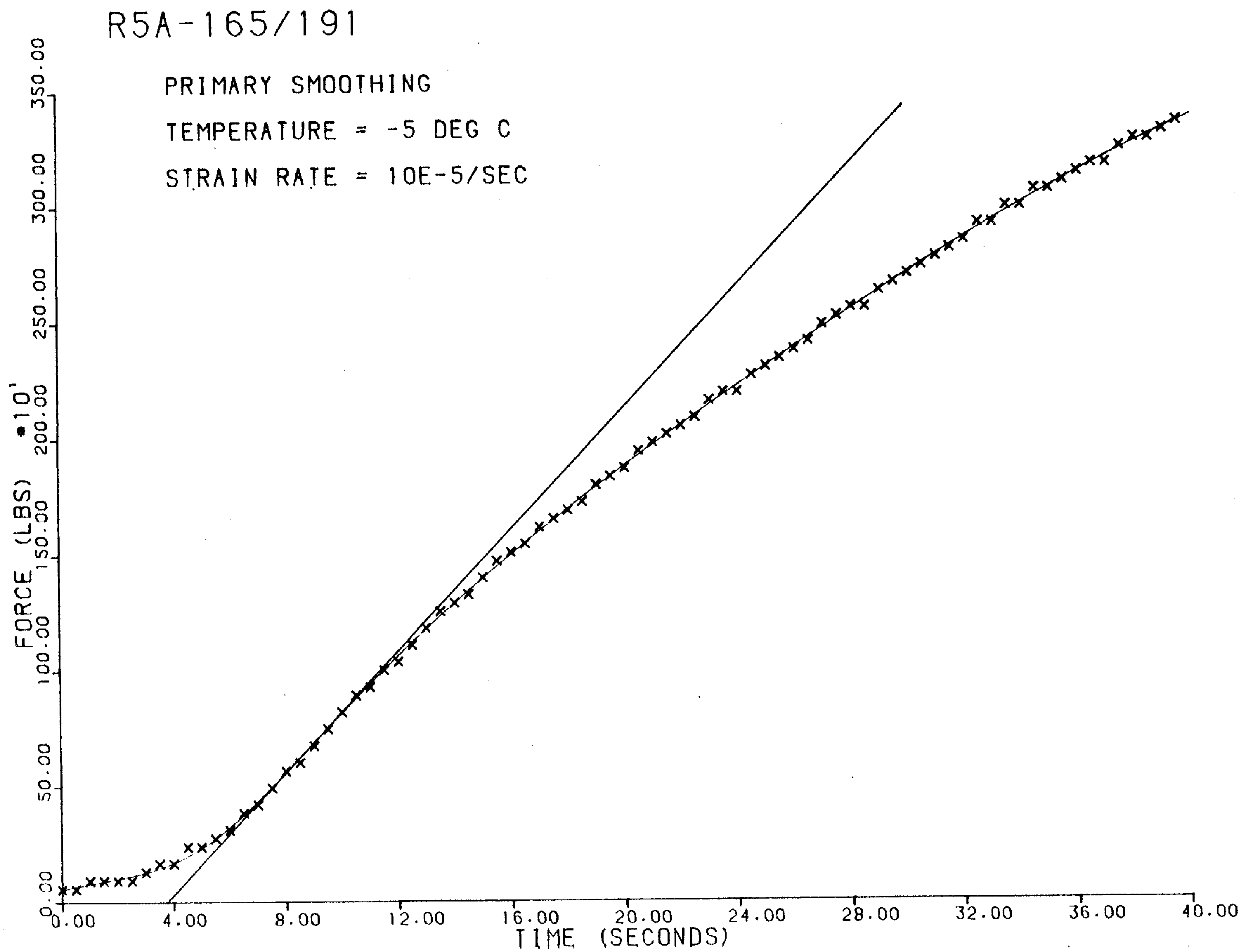

Fig. A-11 - Primary smoothing and tangent at the inflection point for a $\dot{\varepsilon} = 10^{-5}$/sec test.

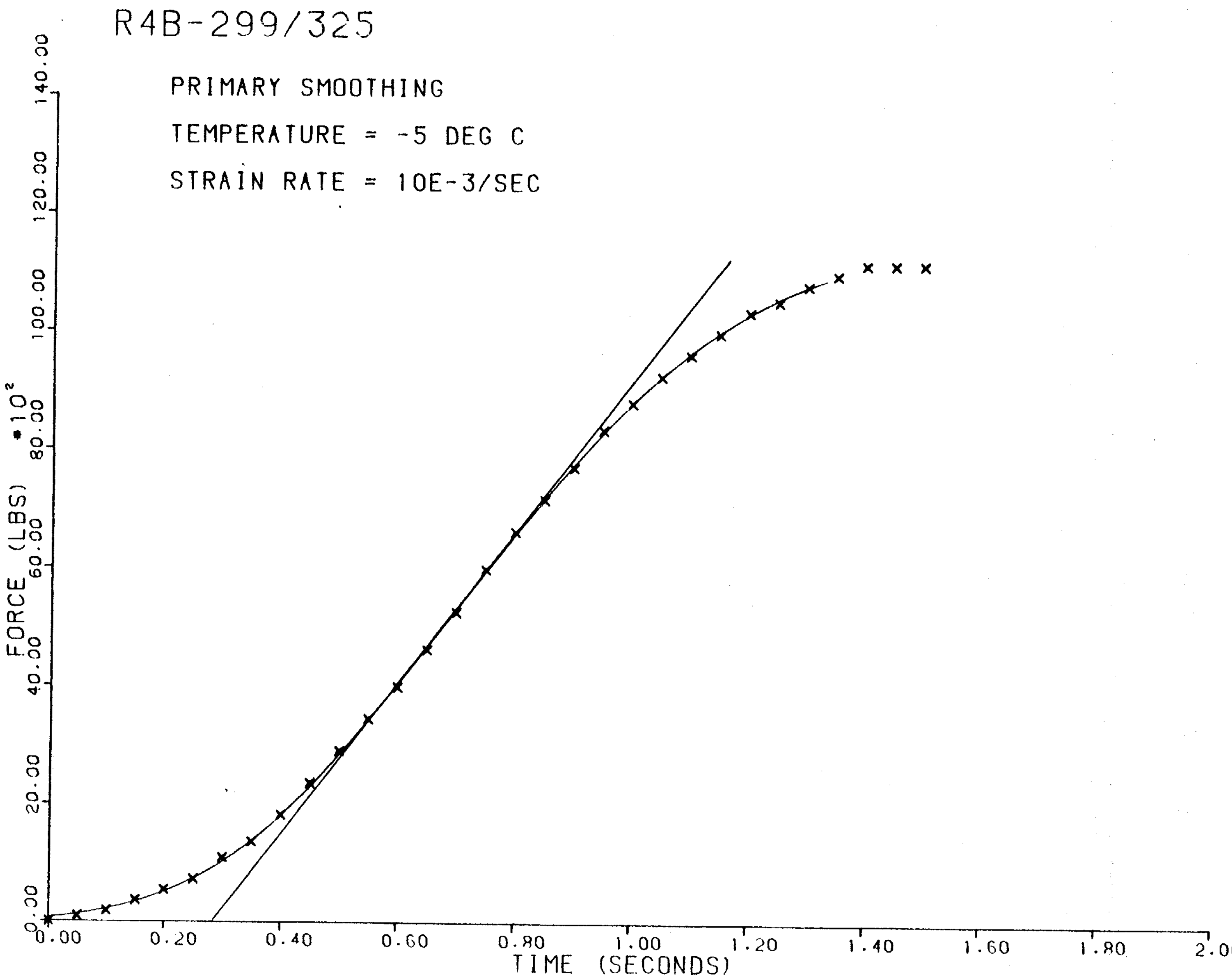

Fig. A-12 - Primary smoothing and tangent at the inflection point for a $\dot{\varepsilon} = 10^{-3}$/sec test.

The next task is to construct an additional spline which connects the initial point of the secondary smoothing with the time axis. This spline is constructed without regard to the data points prior to the initial point of the secondary smoothing, since those points represent the portion of the curve with positive curvature.

The first step in this procedure is to shift the knot index, i, of the quantities returned by the subroutine for the secondary smoothing. The shift is made by increasing the index by one, so that t_i becomes t_2, y_1 becomes y_2, C_{1j}, j = 1, 3, becomes C_{2j}, etc. The secondary smoothing is now described by (k-1) splines $S_i(\xi_i)$, i = 2, k. A schematic diagram illustrating the additional spline along with the secondary smoothing is shown in Figure A-13.

To construct the additional spline, $S_1(\xi_1)$, a local coordinate system is set up at the point $(t_2 - T_1, 0)$. The independent variable for this coordinate system is ξ_1 and covers the range $0 \leq \xi_1 \leq T_1$. The spline, $S_1(\xi_1)$, is found by constructing a cubic polynomial which satisfies the following conditions:

$$\begin{aligned}
&1.\quad S_1(0) = 0 \\
&2.\quad S_1'(0) = F'_{max} \\
&3.\quad S_1''(0) = F_o'' \\
&4.\quad S_1(T_1) = S_2(0) = y_2 \\
&5.\quad S_1'(T_1) = S_2'(0) = C_{21} \\
&6.\quad S_1''(T_1) = S_2''(0) = 2C_{22}
\end{aligned} \tag{2}$$

Here F'_{max} denotes the maximum slope calculated from the primary smoothing. Although the cubic polynomial which we are trying to construct is described by four unknown constants, the six conditions shown above can be satisfied since the quantities T_1 and F_o'' are also considered as unknowns.

Successive elimination of the unknowns in the above conditions yields a quadratic equation in F_o'' with the coefficients being algebraic combinations of the known quantities F'_{max}, y_2, C_{21}, and C_{22}. Solution of this quadratic equation will yield two solutions for F_o''. If one of these solutions is negative, then that solution is chosen to be the correct

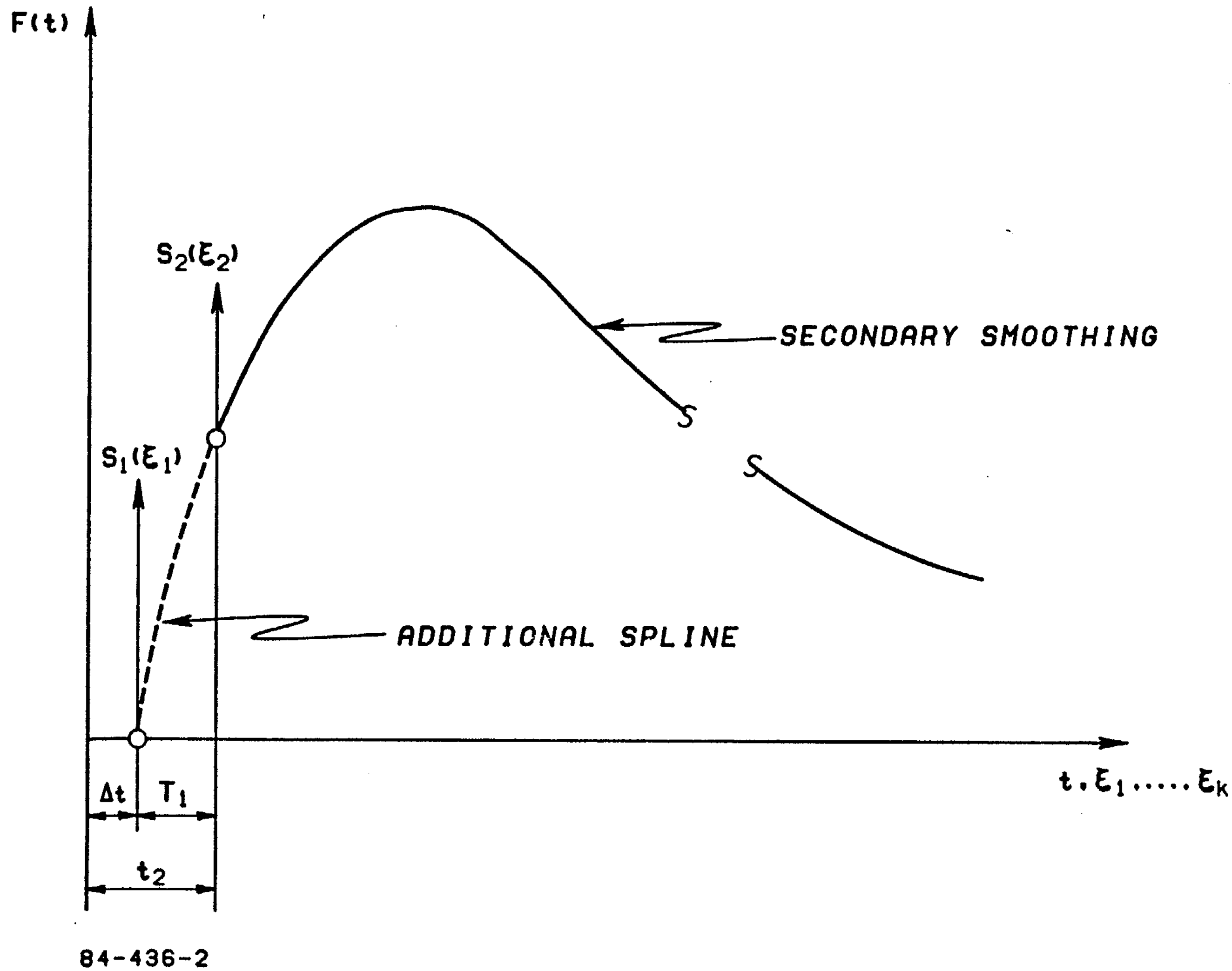

Fig. A-13 - Schematic diagram of the location of the additional spline with respect to the secondary smoothing.

solution. With $F_o'' < 0$, we are guaranteed that the curvature of $S_1(\xi_1)$ will be negative, since we have required that the initial slope of the secondary smoothing be less than F'_{max}. Once the additional spline $S_1(\xi_1)$ is determined, the smoothing procedure is complete. Figure A-14 illustrates the smooth curve obtained for the 10^{-5}/sec test using this procedure. Figure A-15 is an enlarged view of this curve near the origin to illustrate the initial negative curvature of the smooth curve and the continuity at the initial point of the secondary smoothing.

In the event that the quadratic equation for F_o'' yields two positive solutions or two imaginary solutions, the conditions in Equation (2) can be relaxed by adding two splines to the secondary smoothing instead of one. In this case the knot indices, i, for t_i, y_i, and C_{ij}, j = 1, 3, are shifted by two. Figure A-16 illustrates the location of the additional splines after the index shift has been made.

To construct the spline adjacent to the initial point of the secondary smoothing, a local coordinate system is set up at the point $(t_3 - T_2, 0)$. The independent variable for this coordinate system is ξ_2 and covers the range $0 \leq \xi_2 \leq T_2$. The spline, $S_2(\xi_2)$ is found by constructing a cubic polynomial which satisfies the following conditions:

$$\begin{aligned}
&1.\quad S_2'(0) = F'_{max},\\
&2.\quad S_2''(0) = 0,\\
&3.\quad S_2(T_2) = S_3(0) = y_3,\\
&4.\quad S_2'(T_2) = S_3'(0) = C_{31},\\
&5.\quad S_2''(T_2) = S_3''(0) = 2C_{32}.
\end{aligned} \tag{3}$$

The above five conditions are sufficient to solve for the four unknown constants of the cubic polynomial and the unknown time quantity, T_2. Since the initial point of the secondary smoothing is a few points to the right of the inflection point of the primary smoothing, the quantity, $(t_3 - T_2)$ roughly corresponds to the time at which the inflection point occurs in the experimental data.

In a similar manner, the spline to the left of $S_2(\xi_2)$ is found by setting up a local coordinate system at the point, $(t_3 - T_2 - T_1, 0)$ for the independent variable, ξ_1, which covers the range, $0 \leq \xi_1 \leq T_1$. The spline

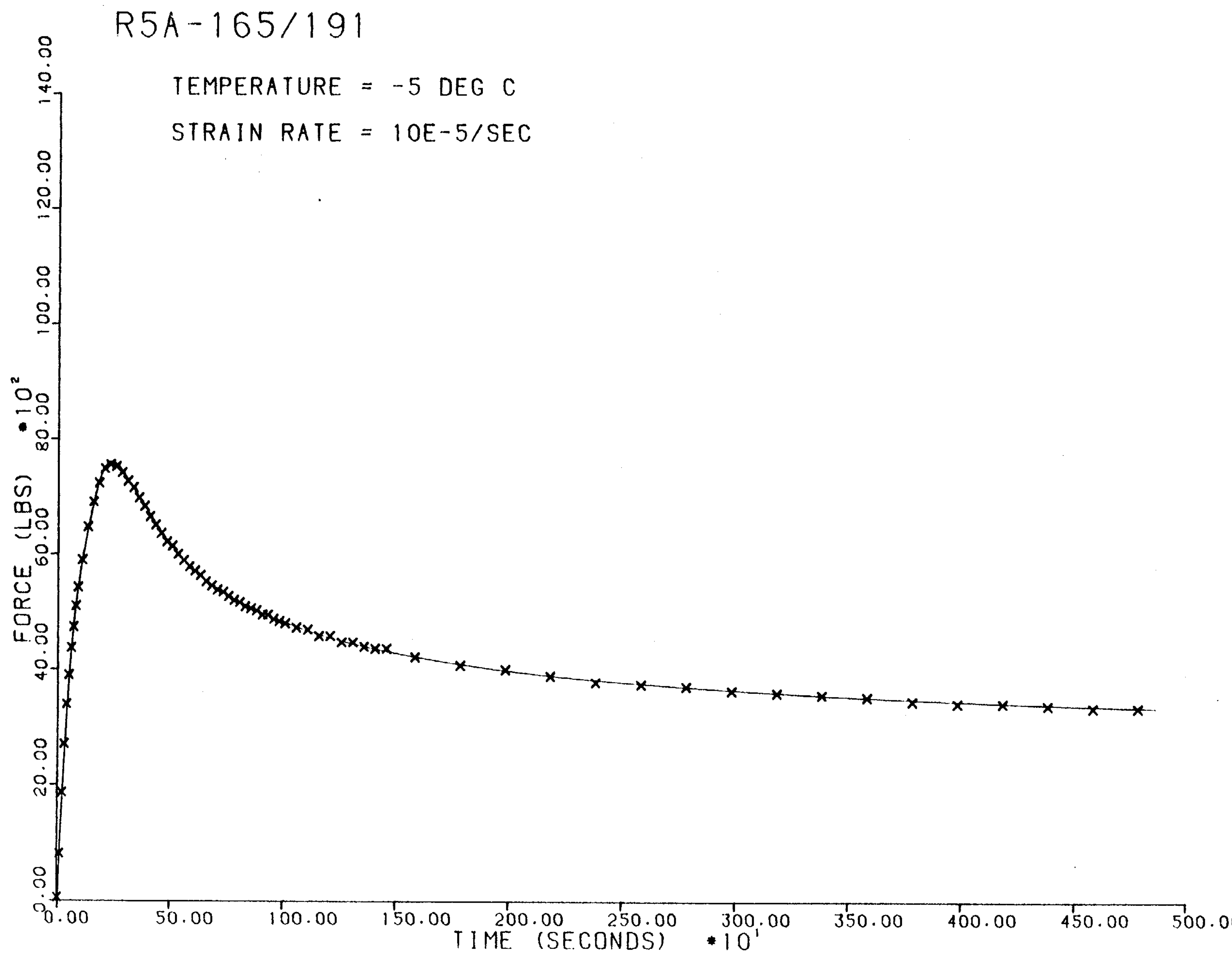

Fig. A-14 - Smooth curve obtained for a $\dot{\varepsilon} = 10^{-5}$/sec test using one additional knot to supplement the secondary smoothing.

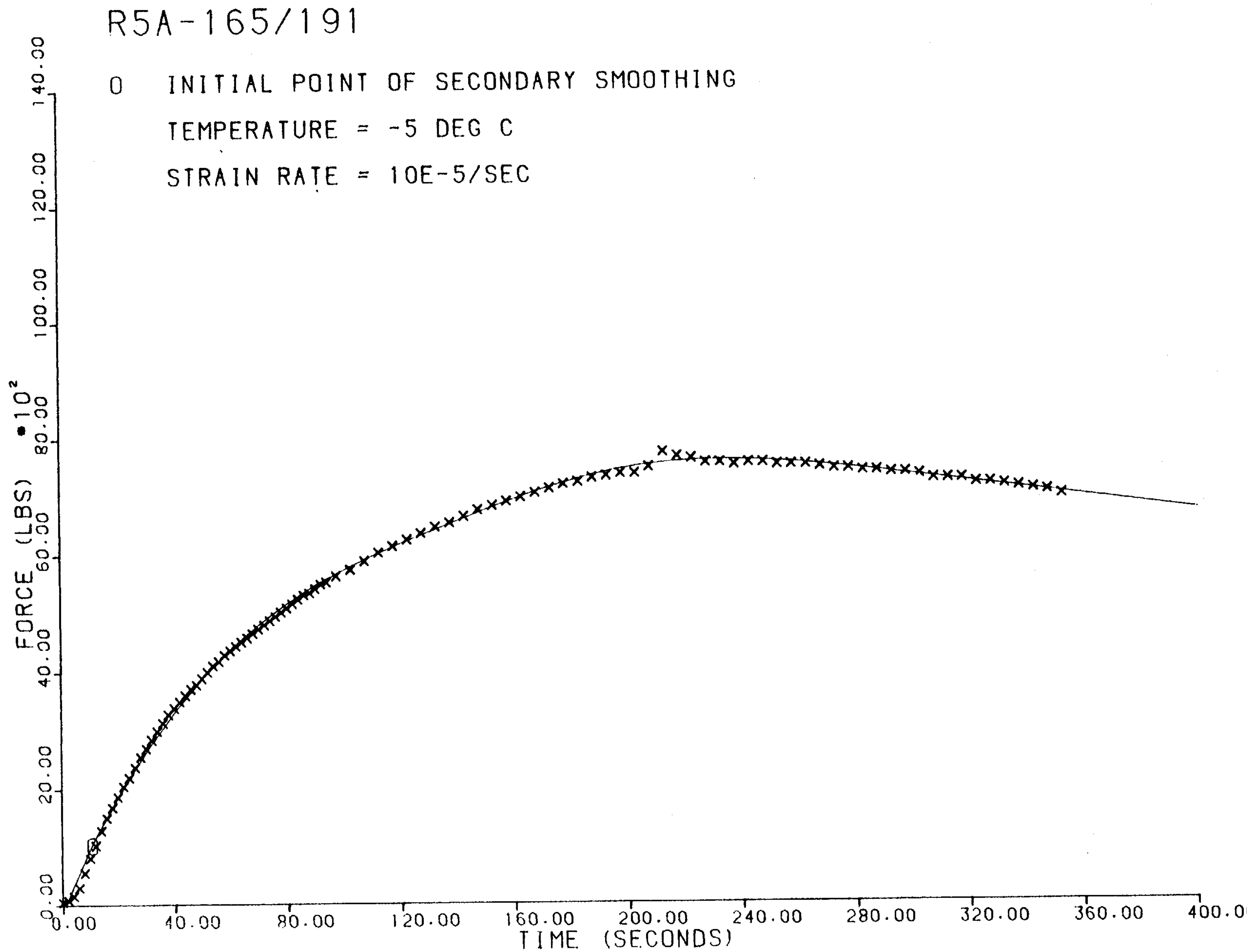

Fig. A-15 - Enlarged view of Figure A-14 near the origin.

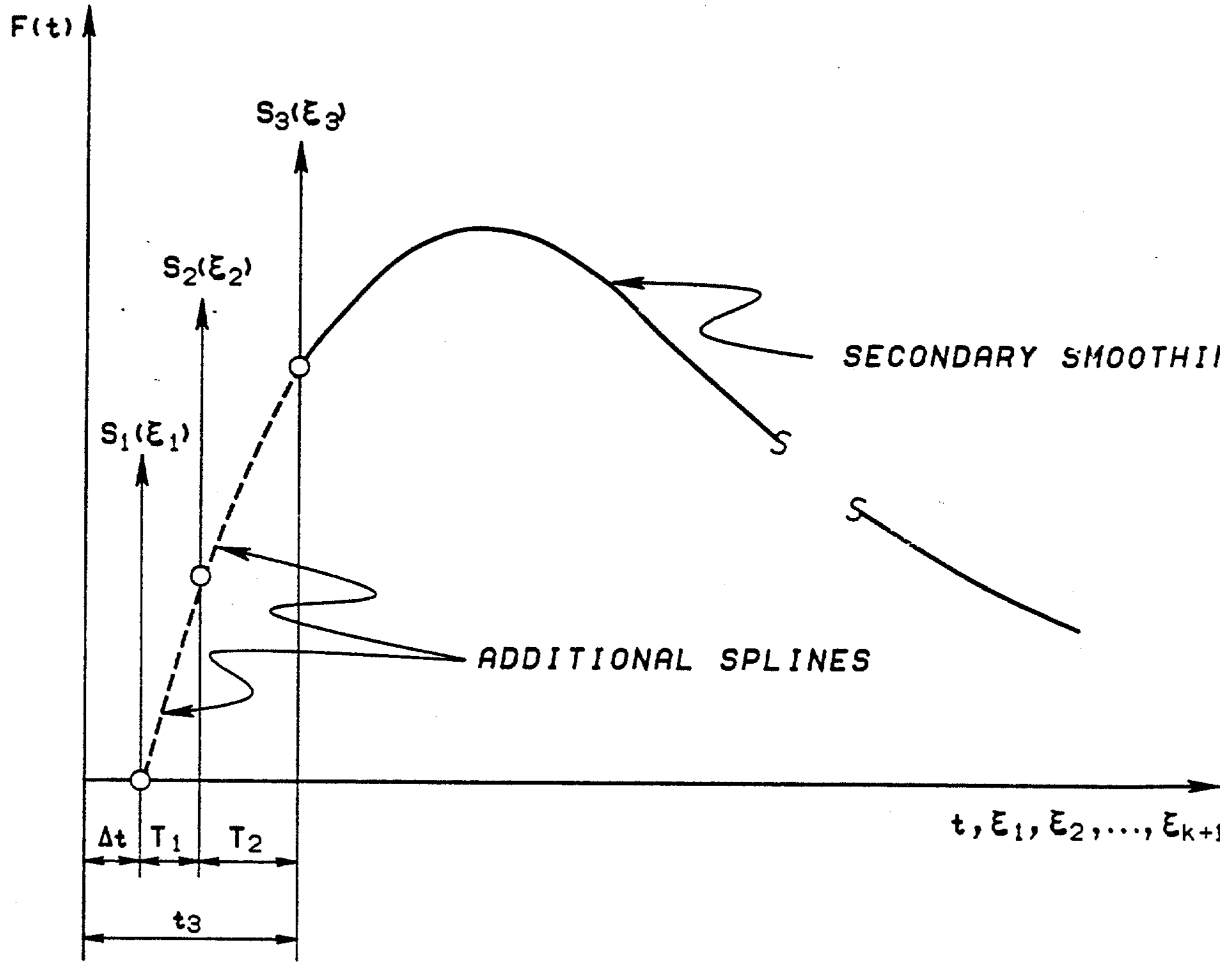

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Fig. A-16 - Schematic diagram of the location of the two additional knots with respect to the secondary smoothing.

$S_1(\xi_1)$ is found by constructing a cubic polynomial which satisfies the following conditions:

$$
\begin{aligned}
&1. \quad S_1(0) = 0, \\
&2. \quad S_1'(0) = F'_{max}, \\
&3. \quad S_1''(0) = 0, \\
&4. \quad S_1(T_1) = S_2(0), \\
&5. \quad S_1'(T_1) = S_2'(0) = F'_{max}.
\end{aligned} \tag{4}
$$

These five conditions are sufficient to find the four unknown constants of the cubic spline, $S_1(\xi_1)$, and the unknown time quantity, T_1. Note that the application of conditions 3 and 5 in Equation (4) collapses the cubic polynomial into a linear curve which automatically forces continuity of the second derivative at T_1.

After the two additional splines are found, the smoothing procedure is completed. Figure A-17 illustrates the type of fit obtained for the 10^{-3}/sec test using the additional two knot procedure. Again, an enlarged view of the fit is shown in Figure A-18 to illustrate the initial linear portion of the smooth curve and the continuity at the initial point of the secondary smoothing.

The particular technique used to determine the initial portion of the smooth curve depends on the initial conditions of the secondary smoothing and the maximum slope found in the primary smoothing. As a general rule, the shape of the 10^{-3}/sec tests is such that two additional knots are required to supplement the secondary smoothing. On the other hand, the 10^{-5}/sec tests seem to favor the technique requiring only one additional knot, although a few of those tests were found which required two knots to complete the smoothing.

The procedures discussed above describe the methods used to fit splines to fully developed force-time curves for both strain rates. These procedures are modified slightly for the 10^{-3}/sec tests which undergo premature failure. The first step in fitting splines for these tests is to determine the appropriate time for the end of the test. Figures A-19 and A-20 illustrate the force and strain time histories of a test having a premature failure. The strain history shows a jump in strain rate at approximately 3.75 seconds. At this time the strain rate deviates from the chosen test

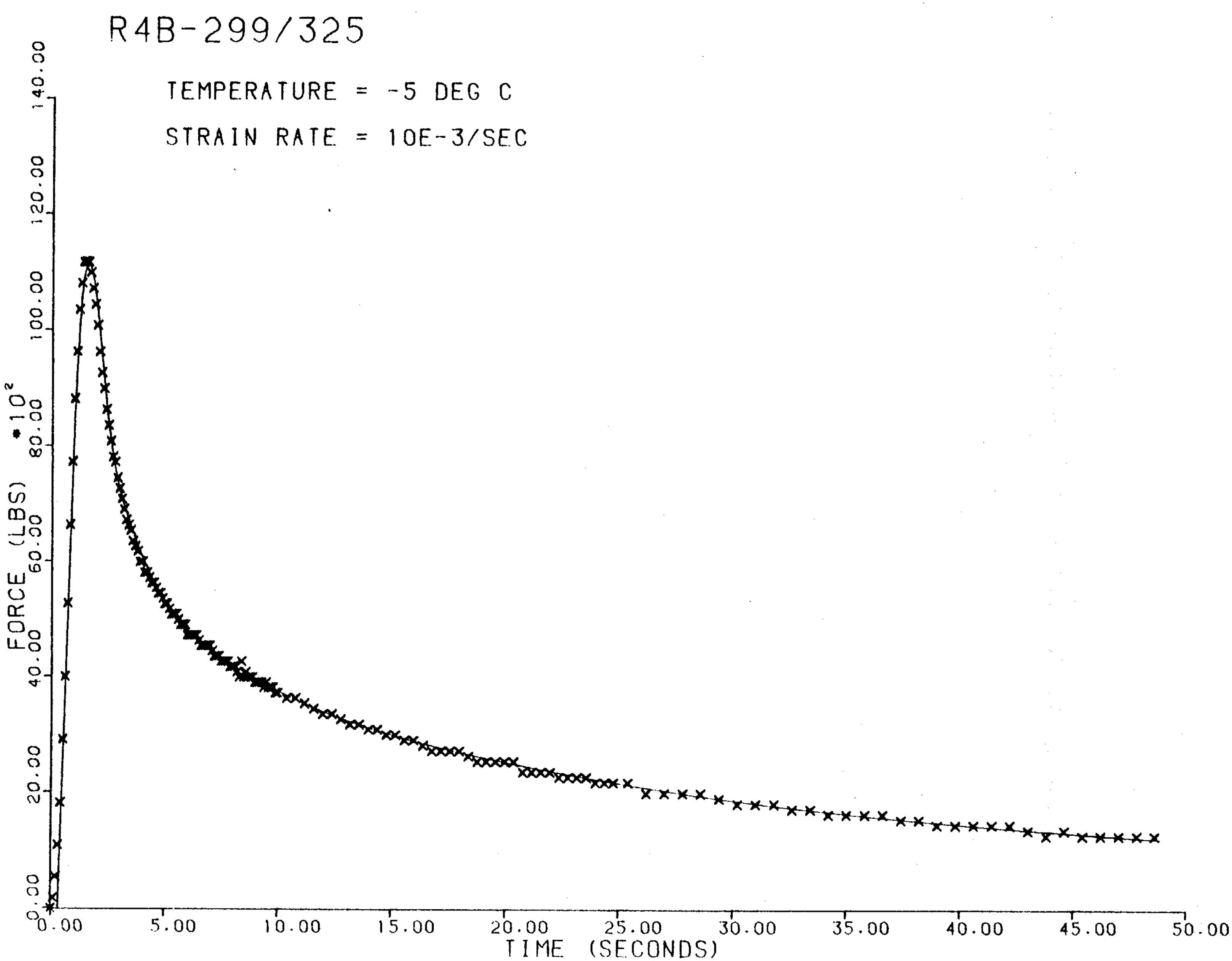

Fig. A-17 - Smooth curve obtained for a $\dot{\varepsilon} = 10^{-3}$/sec test using two additional knots to supplement the secondary smoothing.

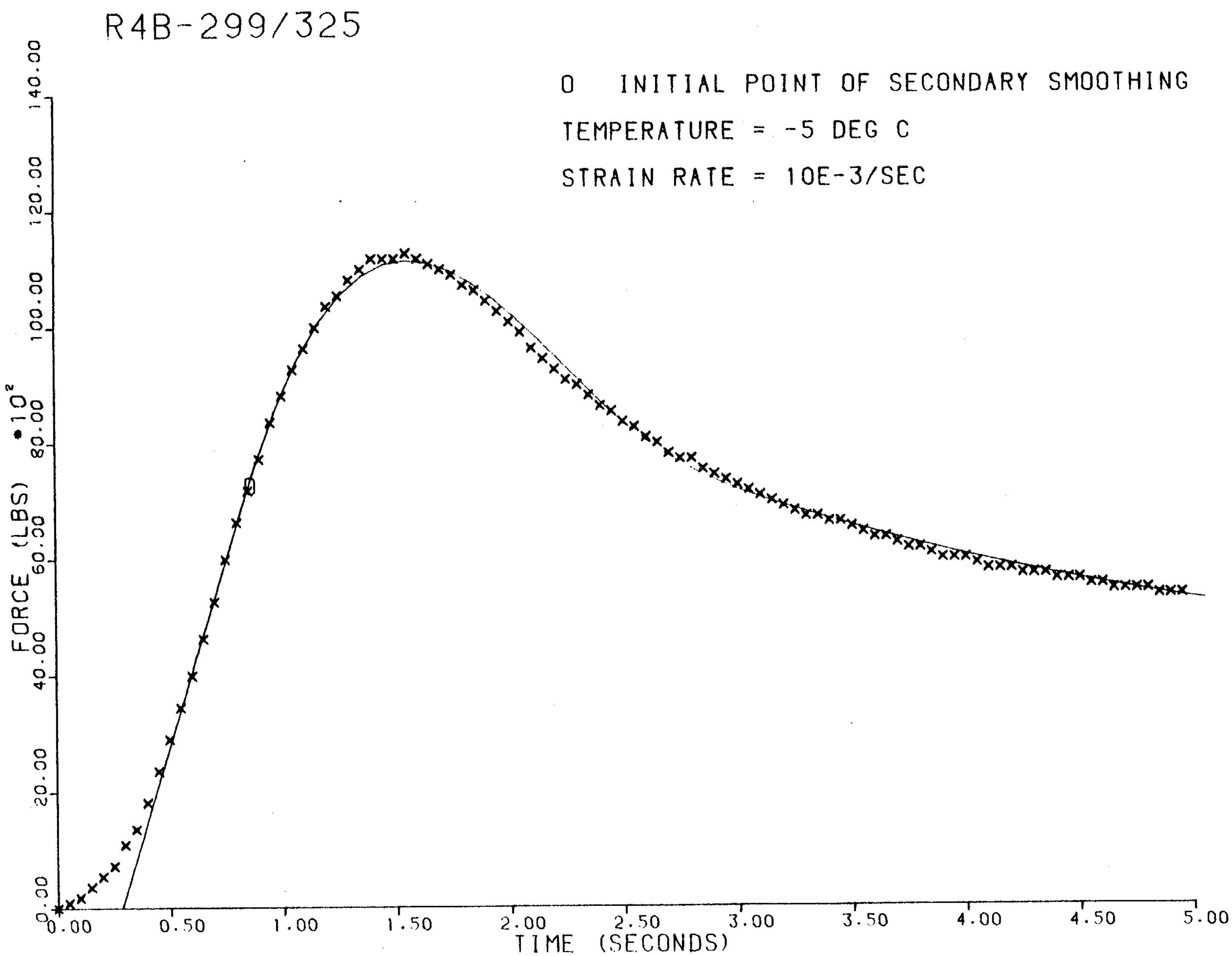

Fig. A-18 - Enlarged view of Figure A-17 near the origin.

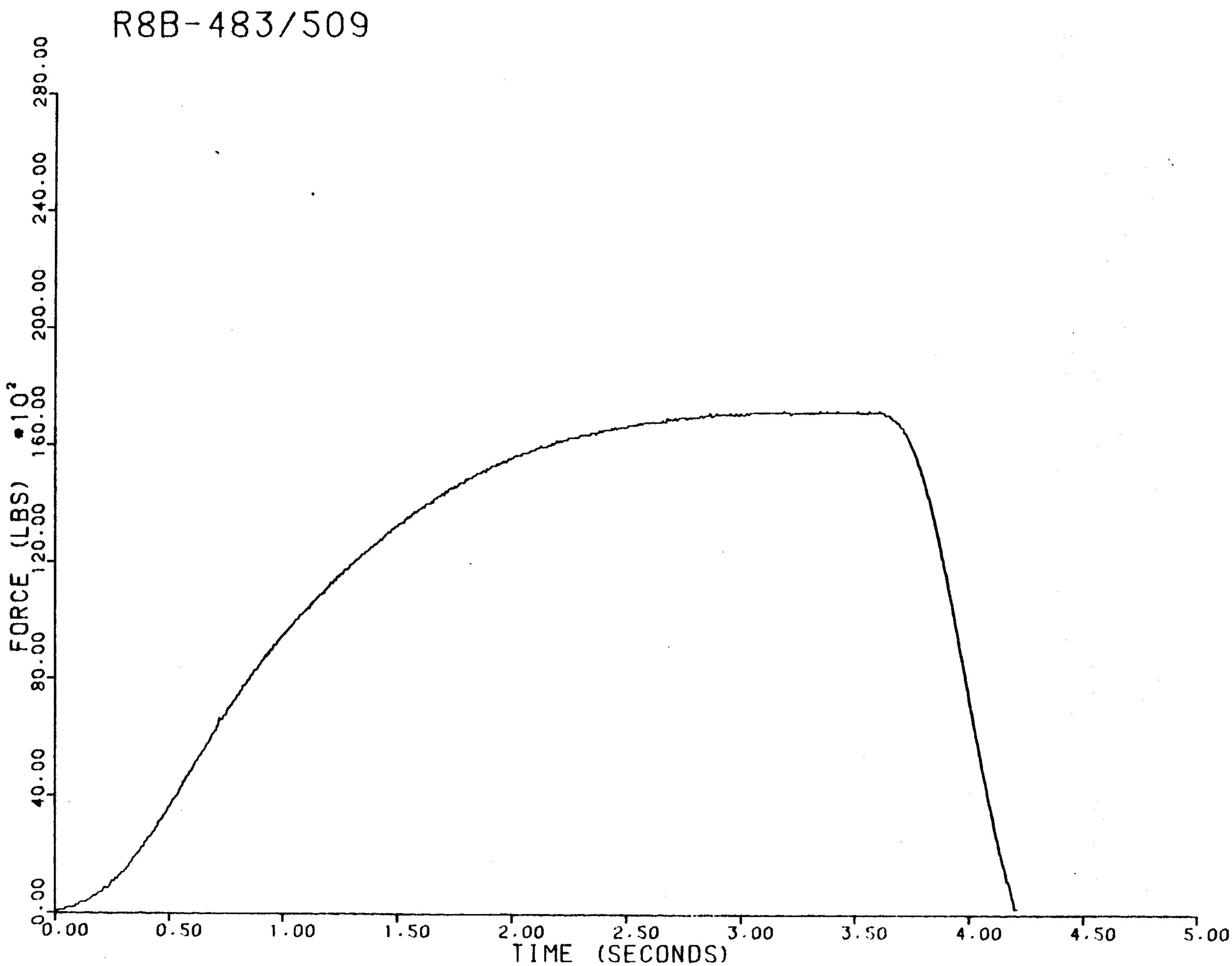

Fig. A-19 - Measured force history of a $\dot{\varepsilon} = 10^{-3}$/sec test with a premature failure.

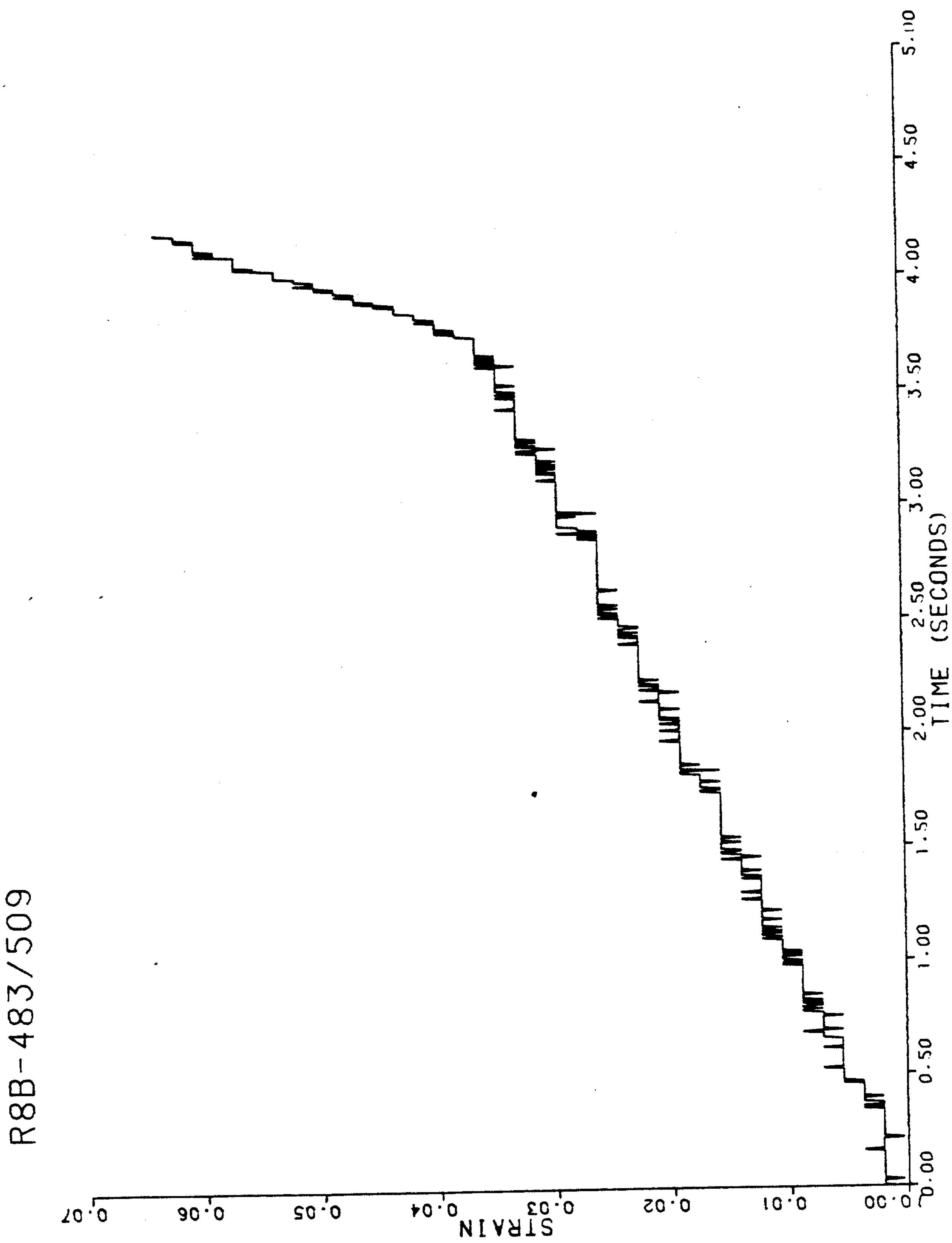

Fig. A-20 - Measured strain history of a $\dot{\varepsilon} = 10^{-3}$/sec test with a premature failure.

strain rate due to rupture of the sample. This time is chosen as the end of the test and all data points beyond this time are eliminated from the force time history.

Once the end of the test is determined, the remaining time record is divided into eight intervals by choosing nine equally spaced knots. Splines are found for each interval, and the maximum slope of the force-time curve is determined by finding the inflection point. All points prior to the inflection point are deleted and replaced by points on the line tangent to the inflection point and extending from the inflection point to the time axis. This method is illustrated schematically in Figure A-21 and is applied by manipulating the indices of the spline parameters and constructing the coefficients of the spline representing the linear portion of the curve. If the inflection point falls between the knots t_i and t_{i+1}, then t_i and all previous knots are deleted from the knot array. The remaining knots are renumbered by changing the i + j index to j + 2 where j = 1, 9-i. A new knot labeled t_2 is then placed at the inflection point, and a new knot labeled t_1 is placed at the intersection of the tangent and the time axis. Thus, the final number of knots is 11-i. The initial values and spline coefficients follow similar index changes. Since the tangent at the inflection point is used for the initial part of the force-time curve, continuity of the function and its first and second derivatives is guaranteed at the inflection point. Figure A-22 illustrates the initial smoothing of the entire time record and the construction of the tangent to the inflection point, and Figure A-23 illustrates the final smoothed force-time curve.

All of the above procedures provide a general approach for smoothing the various types of force-time curves encountered in the data set. However, in some cases, there are situations, such as two inflection points prior to peak stress or local maximum values, which render these procedures unsuitable for application. In these special cases, smooth curves are obtained by judiciously editing the data or by making individual modifications of the above procedures. In all cases, though, every effort is made to yield a consistent set of force-time curves which are faithful to the recorded data and conform to the guidelines discussed previously.

Regardless of the technique used to find the initial portion, the start time of each test is determined by shifting the global force-time coordinate axes to coincide with the local axes, $(\xi_1, S(\xi_1))$. The shift is easily

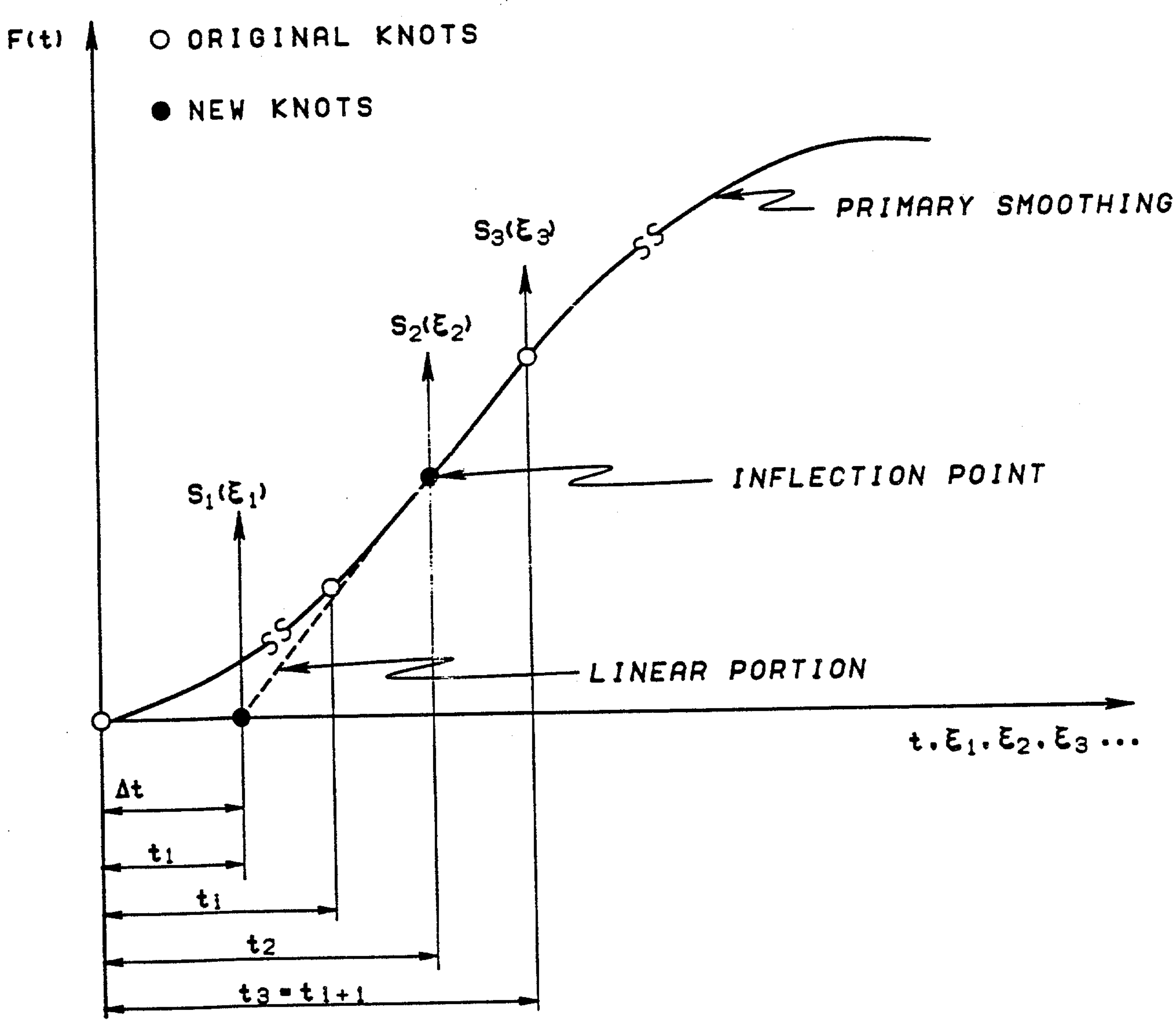

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Fig. A-21 - Schematic diagram of the procedure to smooth tests with a premature failure.

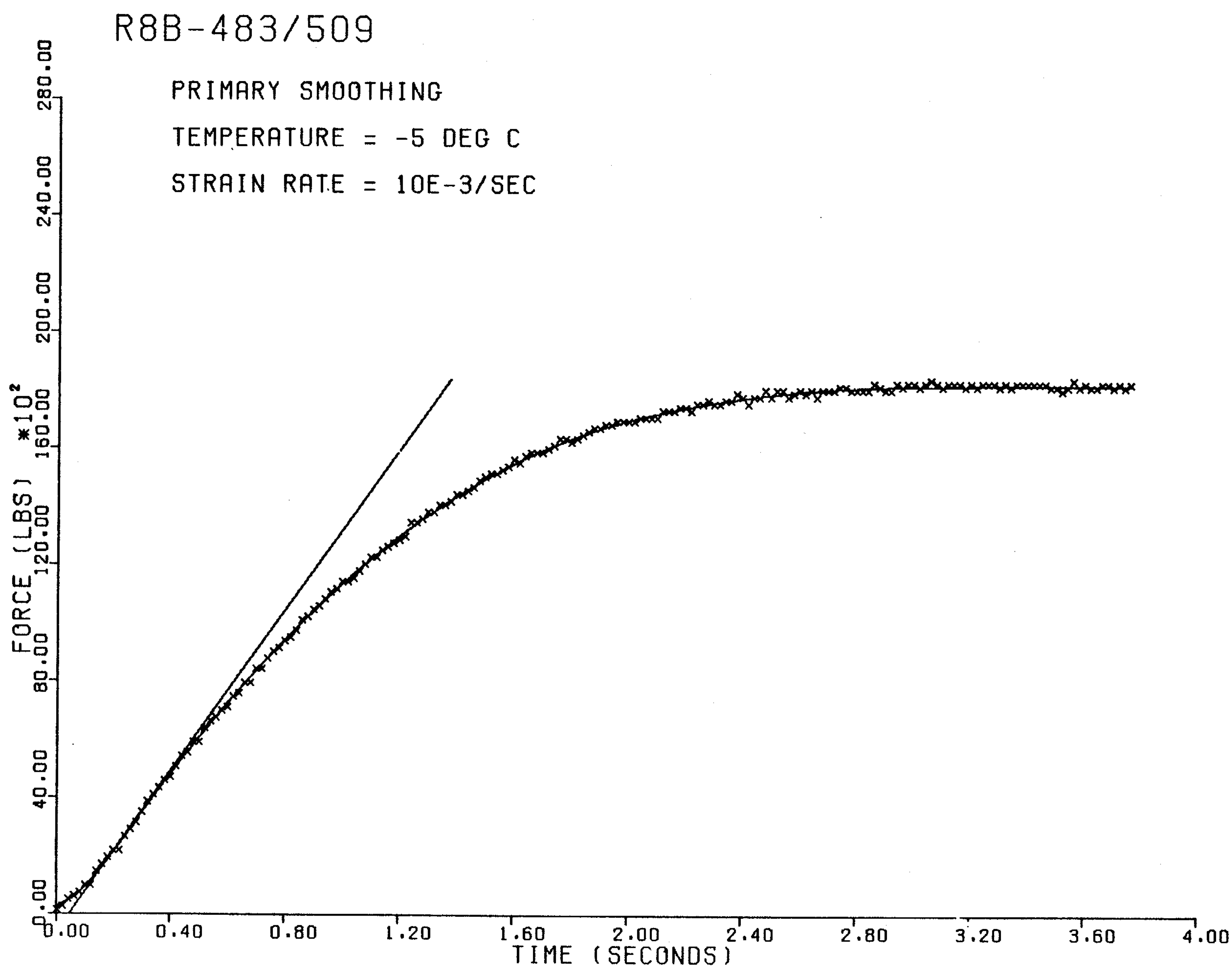

Fig. A-22 - Initial smoothing and the construction of the tangent to the inflection point for a test with a premature failure.

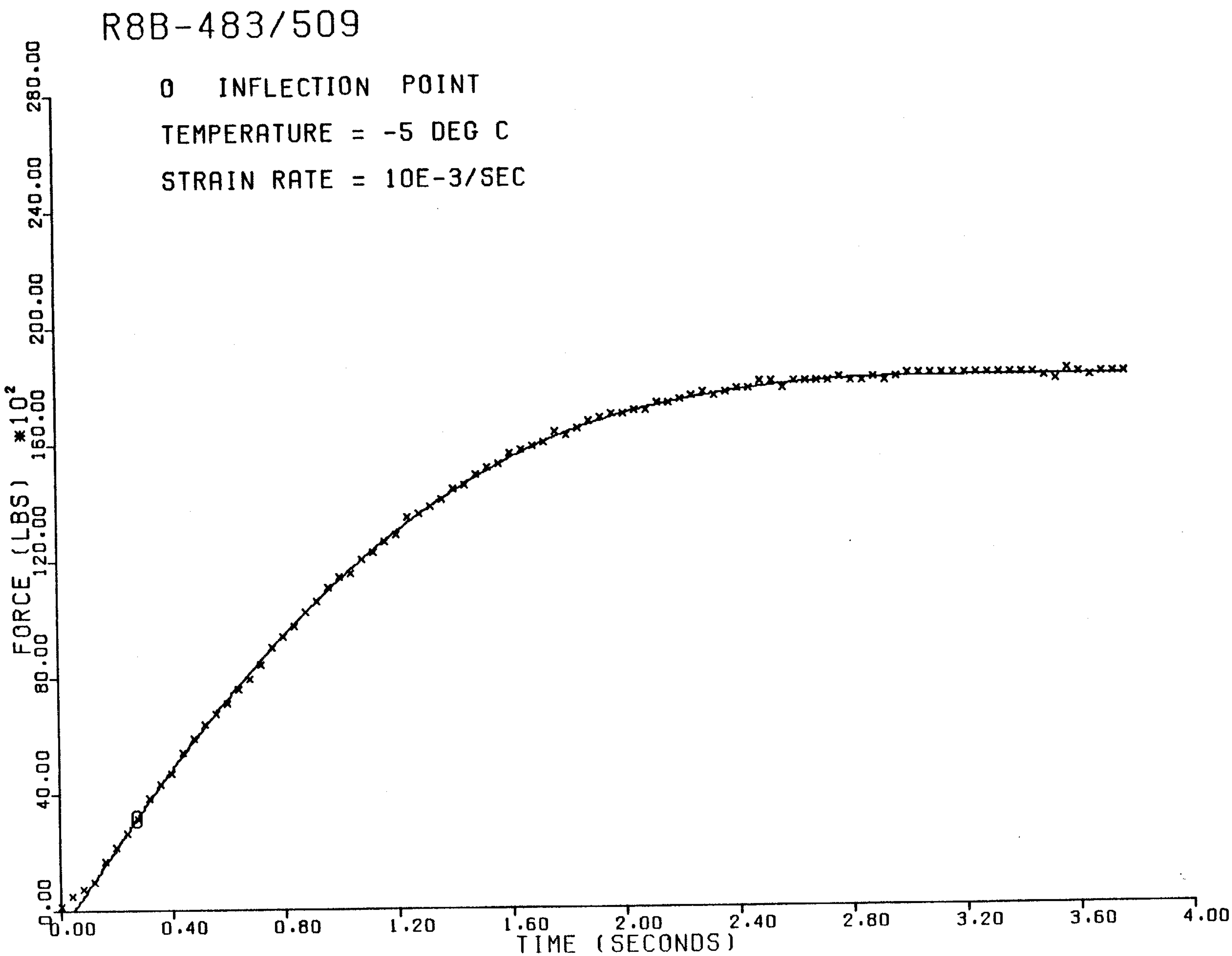

Fig. A-23 - Final smoothing for a test with a premature failure.

made with the coordinate transformation, $\bar{t} = t - \Delta t$, where $\Delta t = t_2 - T_1$ when one additional knot is required, $\Delta t = t_3 - T_2 - T_1$ when two additional knots are required, and $\Delta t = t_1$ when a test has a premature failure. The quantity Δt is illustrated for each technique in Figures A-13, A-16, and A-21. The previously determined splines are valid in the new coordinate system as long as a similar transformation is made for each knot, i.e., $\bar{t}_i = t_i - \Delta t$. The amount of the time shift, Δt, is on the order of 8 sec for the 10^{-5}/sec tests and 0.2 sec for the 10^{-3}/sec tests. In each case the time shift is within the uncertainty of the start time.

After the time shift, the resulting function $F(\bar{t})$ represents the force history of the entire test. If the final number of knots is m, then $F(\bar{t})$ will consist of (m-1) branches, $S_i(\xi_i)$, defined on the intervals, $0 \leq \xi_i \leq \bar{t}_{i+1} - \bar{t}_i$, where $\xi_i = \bar{t} - \bar{t}_i$. The function, F(t), is continuous and has continuous first and second derivatives at every point. Furthermore, the maximum slope of $F(\bar{t})$ occurs at the origin and is equal to the maximum slope of the experimental data. The composite function is completely defined by the knots, $\bar{t}_i$, i = 1, m, the initial value of each spline, y_i, i = 1, (m-1), and the spline coefficients, C_{ij}, i = 1, (m-1), j = 1, 3. These values are tabulated in data files for each test and are shown in Table A-1 for test number R5A-165/191, Table A-2 for test number R4B-299/325, and Table A-3 for R8B-483/509.

As a final step, the strain history is shifted by the amount, Δt. Two knots are chosen at the beginning and end of the strain history and a cubic spline is found by calling the subroutine ICSVKU. This step is unnecessary since the strain history is linear for a constant strain rate test, but it does provide a check on the test strain rate. The check is made by comparing the coefficients returned by the subroutine. If the cubic and quadratic coefficients are several orders of magnitude smaller than the linear coefficient and if the linear coefficient is within 1% ofthe test strain rate, then the test is considered valid.

Once this check is completed, the force-time curve, $F(\bar{t})$ is used to generate the stress-strain curve by scaling the coordinate axes. The force axis is divided by the original cross-sectional area of the test sample and the time axis is multiplied by the test strain rate. The stress strain curves for test numbers R5A-165/191, R4B-299/325, and R8B-483/509 are shown in Figures A-24, A-25, and A-26, respectively.

Table A-1

SPLINE PARAMETERS FOR R5A-165/191

R5A-165/191
Temperature = -5°C
Strain Rate = 10E -5/Sec

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
1	.00000	.00000	130.85	-3.6589	.11879
2	8.5945	929.77	94.283	-.59617	.15679-02
3	72.798	4940.6	37.120	-.29418	.15703-02
4	137.00	6526.7	18.763	-.82711-02	-.95727-03
5	201.20	7512.1	7.9873	-.17611	.82803-03
6	216.20	7595.1	3.2630	-.13885	.79035-03
7	269.45	7494.5	-4.8010	-.12609-01	.35774-04
8	472.95	6296.8	-5.4883	.92319-02	-.82040-05
9	787.00	5229.6	-2.1172	.15026-02	-.50542-06
10	1603.2	4227.7	-.67447	.26502-03	-.50521-07
11	2894.1	3690.0	-.24280	.69364-04	-.14443-07
12	4870.2				

Table A-2

SPLINE PARAMETERS FOR R4B-299/325

R4B-299/325
Temperature = -5°C
Strain Rate = 10E -3/Sec

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
1	.00000	.00000	12769.	.00000	.00000
2	.54611	6973.2	12769.	.00000	-.33446+06
3	.55794	7123.8	12628.	-11878.	2825.1
4	.82794	9723.2	6832.2	-9589.6	2906.2
5	1.0979	10926.	2289.4	-7235.6	2671.8
6	1.3479	11088.	-827.47	-5231.7	2937.4
7	1.5979	10600.	-2892.6	-3028.7	2816.6
8	2.2723	8135.6	-3134.6	2669.9	-1241.2
9	2.9309	6874.7	-1232.9	217.53	-16.225
10	7.1064	4338.0	-264.98	14.290	-.37480
11	18.190	2646.3	-86.343	1.8275	-.18087-01
12	48.628				

Table A-3

SPLINE PARAMETERS FOR R8B-483/509

R8B-483/509
Temperature = -5°C
Strain Rate = 10E -3/Sec

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
1	.00000	.00000	13828.	.00000	.00000
2	.20898	2889.8	13828.	.00000	-54684.
3	.23329	3225.2	13737.	-3866.6	751.57
4	.59068	7675.1	11261.	-3060.8	-299.87
5	1.0609	12263.	8183.4	-3483.8	240.55
6	1.8089	16535.	3375.5	-2944.1	1434.3
7	2.3024	17656.	1517.6	-820.76	-1279.9
8	2.4717	17883.	1129.7	-1470.9	662.31
9	3.4310	18198.	136.23	435.26	-3364.5
10	3.7131				

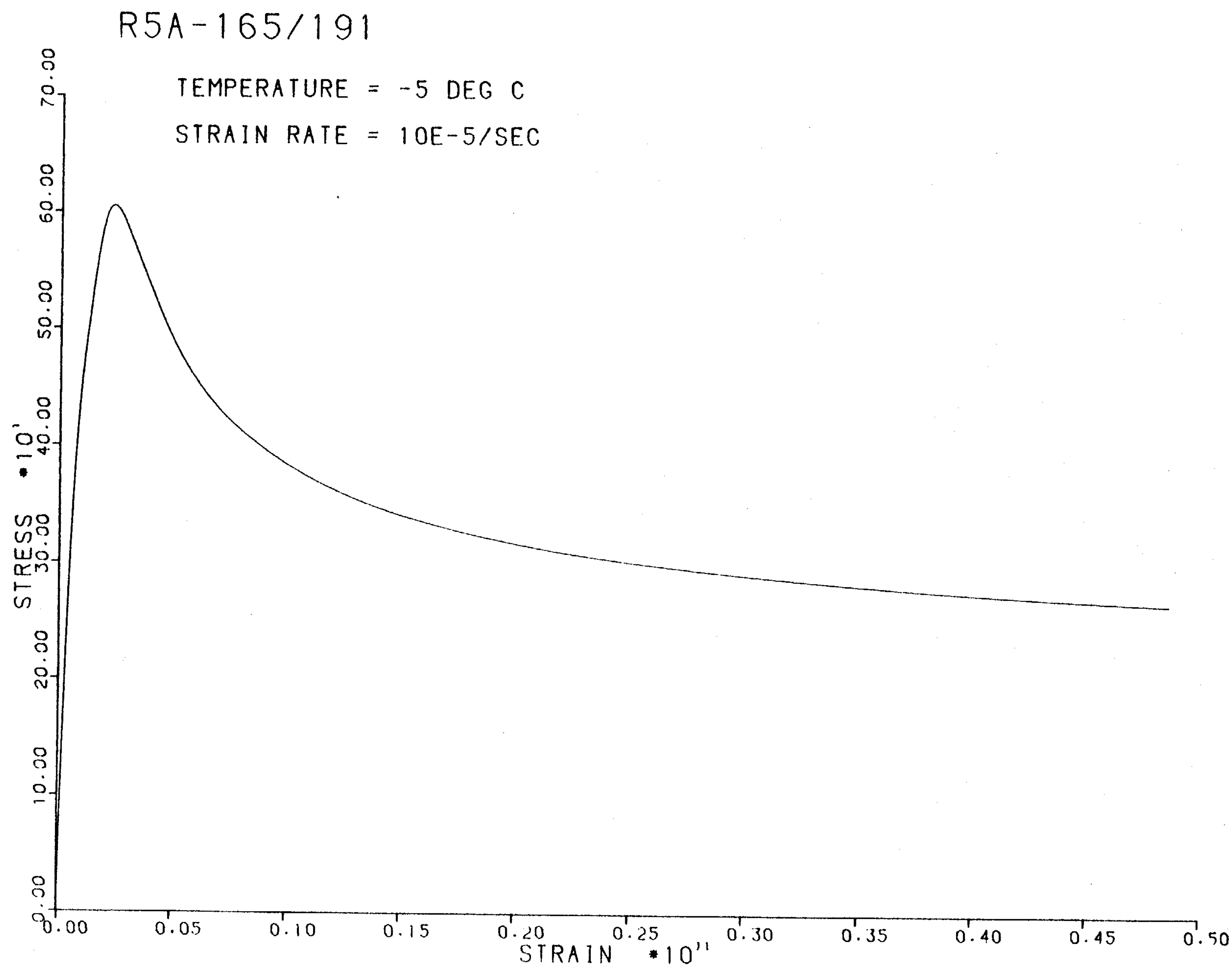

Fig. A-24 - Final stress-strain curve for a $\dot{\varepsilon} = 10^{-5}$/sec test.

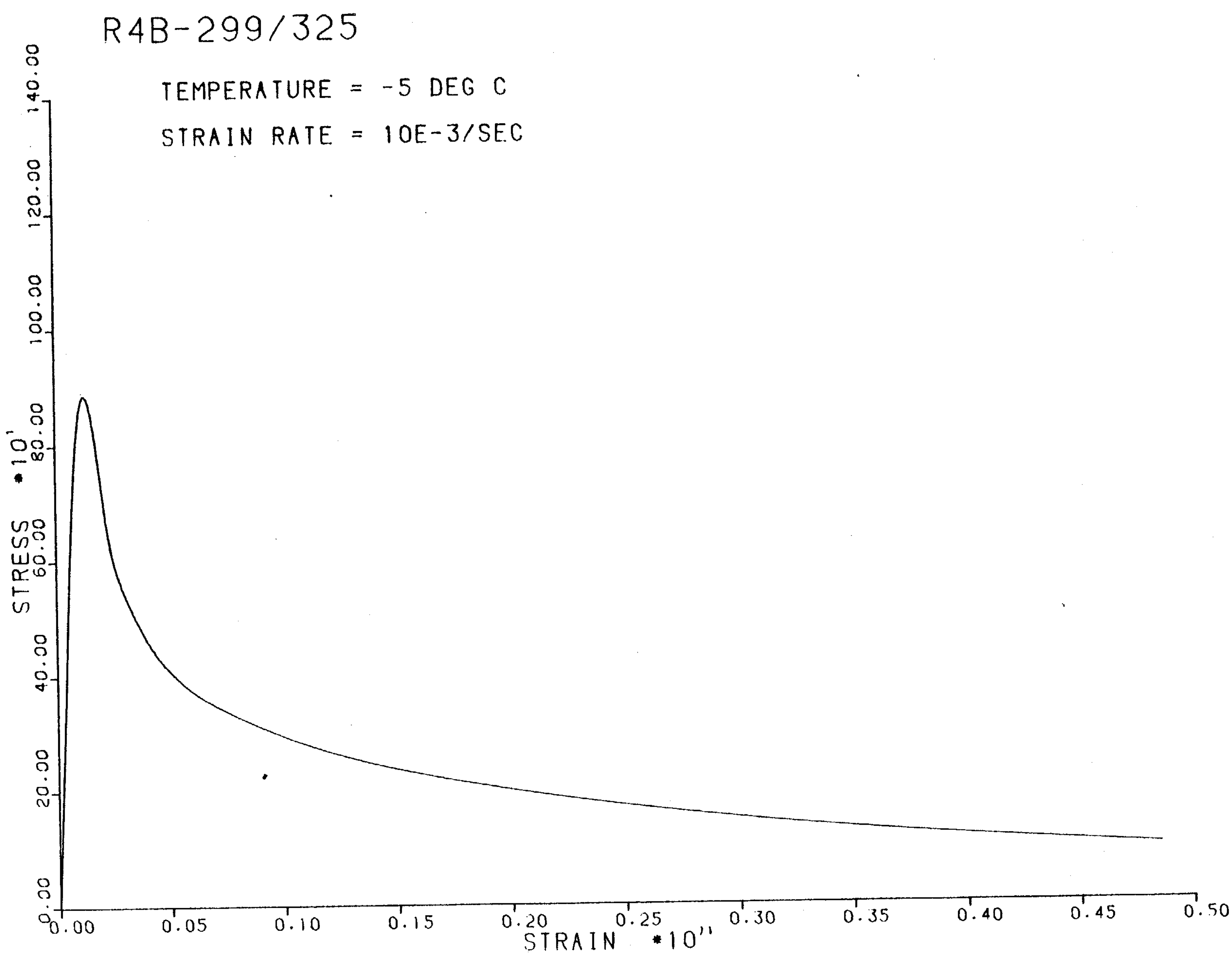

Fig. A-25 - Final stress-strain curve for a $\dot{\varepsilon} = 10^{-3}$/sec test.

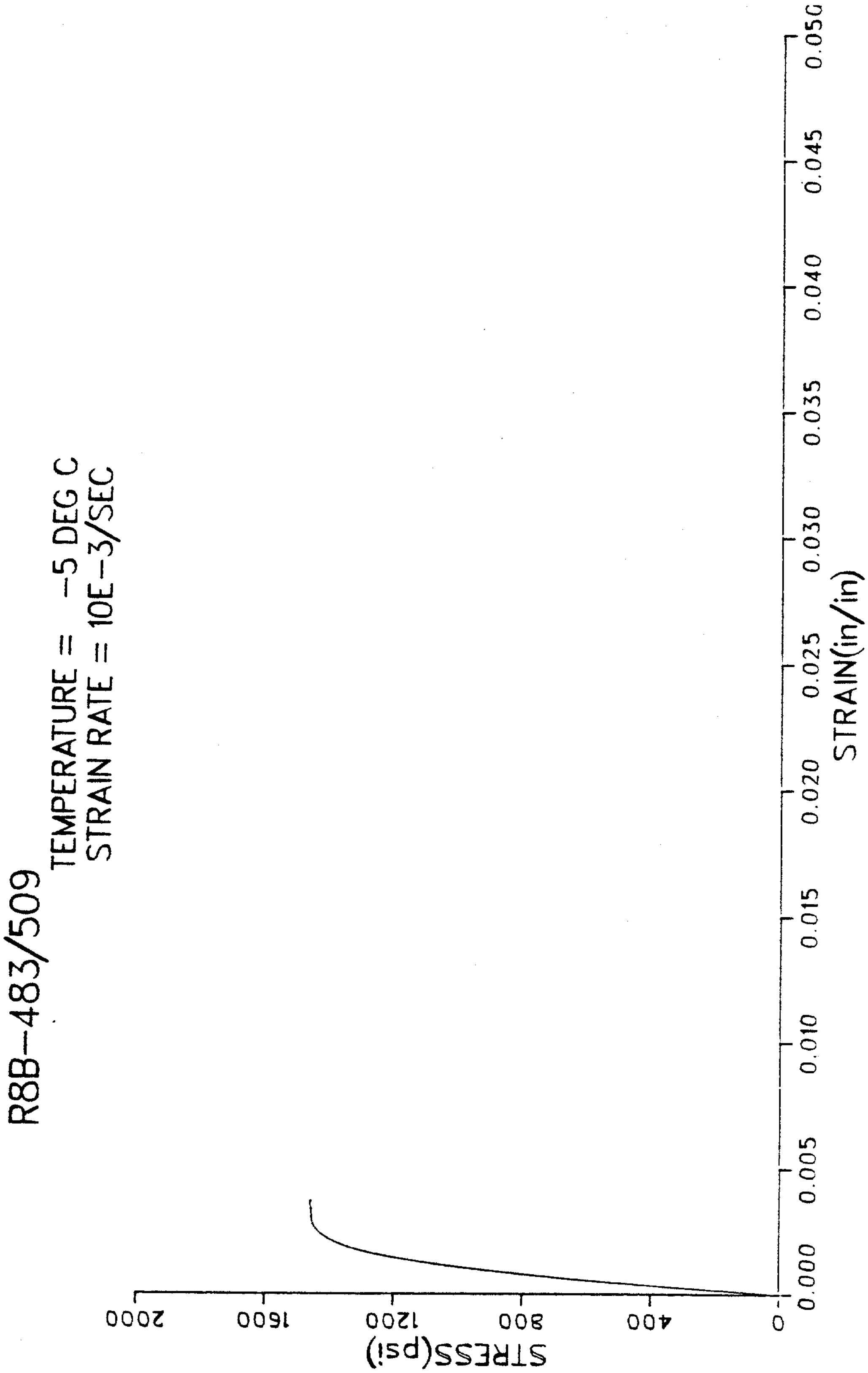

Fig. A-26 - Final stress-strain curve for a test with a premature failure.

THE UNIAXIAL MECHANICAL RESPONSE OF MULTI-RIDGE ICE

VOLUME III
APPENDIX B - CUBIC SPLINES FORCE-TIME HISTORIES

BY

J. F. DORRIS AND J. S. AUSTIN

TECHNICAL PROGRESS REPORT

BRC 45-85
OCTOBER 1985

Project No. 327-27802.34
Mechanical Properties of Sea Ice

Reviewed by: E.G. Ward
E.N. Earle
Participant: C.A. Gutierrez
Released by: J.H. Lybarger
Reference: Based on work through December 1983.

Appendix B

CUBIC SPLINES FOR FORCE-TIME HISTORIES

Appendix B

SPLINE COEFFICIENTS FOR
FORCE-TIME HISTORIES

STRAIN RATE = (10E-5)/SEC
TEMPERATURE = -5°C

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R1A-062/089					
1	.00000	.00000	121.23	-5.4627	.24820
2	6.4955	624.96	81.675	-.62622	.18114-02
3	115.34	4431.7	9.7334	-.34746-01	.43490-04
4	243.22	5199.2	2.9804	-.18061-01	.21083-04
5	399.20	5304.6	-1.1151	-.81952-02	.96485-05
6	473.44	5180.6	-2.1723	-.60464-02	.29435-04
7	569.66	4941.8	-2.5183	.24506-02	-.14877-05
8	921.02	4295.0	-1.3472	.88241-03	-.44503-06
9	1359.3	3836.6	-.83024	.29730-03	.44105-07
10	2180.3	3379.8	-.25291	.40592-03	-.51000-06
11	2482.9	3326.3	-.14735	-.57124-04	.27582-07
12	4848.8				
R1B-062/089					
1	.00000	.00000	58.669	-1.7297	.55603-01
2	8.9335	425.72	41.077	-.23951	.56948-03
3	150.50	3056.6	7.5037	.23453-02	-.12252-03
4	235.43	3635.7	5.2504	-.28875-01	.68527-04
5	343.02	3951.7	1.4169	-.67565-02	.41557-05
6	589.00	3953.3	-1.1527	-.36899-02	.81864-05
7	799.57	3623.4	-1.6177	.14815-02	-.17889-05
8	1104.3	3217.4	-1.2131	-.15376-03	.36386-05
9	1313.3	2990.4	-.80068	.21274-02	-.34903-05
10	1494.7	2894.3	-.37338	.22734-03	-.55753-07
11	3151.3	2646.2	-.79164-01	-.49733-04	.51011-07
12	4870.3				
R2A-140/165					
1	.00000	.00000	61.973	.00000	.00000
2	9.7479	604.10	61.973	.00000	-.66951-01
3	12.128	750.73	60.834	-.47813	.12504-02
4	165.14	3344.0	2.3375	.95839-01	-.56882-03
5	240.69	3822.4	7.0785	-.33086-01	.74459-04
6	372.77	4351.7	2.2354	-.35826-02	-.49437-05
7	557.12	4611.0	.41040	-.63167-02	.18470-04
8	669.27	4603.7	-.30952	-.10284-03	-.17013-05
9	1086.0	4333.7	-1.2816	-.22297-02	.49337-04
10	1171.1	4238.9	-.58860	.10370-01	-.14163-03
11	1202.7	4226.2	-.35711	-.30293-02	.59884-05
12	1384.5	4097.1	-.86475	.23832-03	-.24702-07
13	4852.1				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
-----	------	------	------	------	------
R2B-094/121					
1	.00000	.00000	25.204	.00000	.00000
2	46.852	1180.9	25.204	.00000	-.59923-01
3	48.141	1213.2	24.905	-.23160	.69691-03
4	80.641	1801.9	12.060	-.16365	.72269-03
5	113.14	2045.8	3.7131	-.93184-01	.70672-03
6	145.64	2092.3	-.10445	-.24279-01	.13876-03
7	160.64	2085.8	-.73916	-.18035-01	.13508-03
8	205.47	2028.6	-1.5418	.13002-03	.65339-05
9	382.93	1795.6	-.87826	.36087-02	-.70950-05
10	503.03	1729.9	-.31847	.10524-02	-.80112-06
11	921.01	1722.1	.14141	.47847-04	-.16529-07
12	2854.7	2054.9	.14104	-.48038-04	.52417-08
13	4889.0				
R3A-106/131					
1	.00000	.00000	41.464	.00000	.00000
2	6.4259	266.44	41.464	.00000	-.34620-02
3	25.226	1022.9	37.793	-.19525	.41063-03
4	148.44	3483.5	8.3792	-.43464-01	.98149-04
5	261.56	4017.2	2.3139	-.10157-01	.14484-04
6	457.64	4189.6	.12273-02	-.16371-02	.51214-06
7	551.78	4175.6	-.29340	-.14924-02	.24962-05
8	764.63	4069.6	-.58946	.10151-03	-.12679-06
9	1168.2	3840.0	-.56947	-.51968-04	.76515-06
10	1357.7	3735.3	-.50669	.38320-03	-.65556-06
11	1471.5	3681.7	-.44496	.15951-03	-.49682-07
12	1863.2	3528.9	-.34285	.10112-03	-.13412-07
13	4847.9				
R3B-161/187					
1	.00000	.00000	29.018	.00000	.00000
2	50.188	1456.4	29.018	.00000	-.42464-02
3	62.404	1803.1	27.117	-.15562	.36789-03
4	167.57	3361.6	6.5905	-.39555-01	.97276-04
5	251.30	3693.2	2.0125	-.15120-01	.26794-04
6	426.65	3725.6	-.81858	-.10252-02	-.23029-05
7	499.77	3659.4	-1.0054	-.15304-02	.57817-05
8	660.07	3482.7	-1.0504	.12500-02	-.18166-05
9	829.06	3332.1	-.78355	.32903-03	-.17235-07
10	1149.8	3114.1	-.57782	.31245-03	-.98471-07
11	1470.5	2957.7	-.40780	.21771-03	-.58627-07
12	2517.8	2702.1	-.14469	.33513-04	-.23631-08
13	4860.6				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R4A-312/338					
1	.00000	.00000	60.554	-2.1260	.11865
2	5.0575	267.22	48.153	-.32588	.79478-03
3	151.41	2826.0	3.8377	.23086-01	-.18184-03
4	239.23	3217.9	3.6858	-.24817-01	.71250-04
5	350.46	3418.9	.80951	-.10414-02	-.10746-04
6	503.63	3479.8	-.26586	-.59794-02	.26959-04
7	570.39	3443.5	-.70377	-.58052-03	.95143-06
8	879.44	3198.6	-.78997	.30161-03	.16921-07
9	1359.7	2890.6	-.48855	.32599-03	-.19046-06
10	1713.7	2750.1	-.32935	.12372-03	-.20643-07
11	3147.7	2471.4	-.10186	.34918-04	-.10381-07
12	4862.7				
R4B-328/354					
1	.00000	.00000	26.570	-.63332-01	-.17580-03
2	58.371	1300.2	17.379	-.94117-01	.23525-03
3	183.44	2461.8	4.8765	-.58528-02	-.41129-04
4	258.48	2777.4	3.3033	-.15112-01	.29574-04
5	383.54	3012.0	.91111	-.40156-02	-.44990-06
6	499.57	3063.0	-.38907-01	-.41723-02	.12513-04
7	564.45	3046.3	-.42229	-.17366-02	.24247-05
8	818.81	2866.4	-.83511	.11365-03	.21886-06
9	1147.5	2612.0	-.68948	.32944-03	-.67669-07
10	1959.2	2263.8	-.32336	.18495-03	-.52184-07
11	2817.3	2077.8	-.11266	.34964-04	-.50906-08
12	4776.5				
R5A-165/191					
1	.00000	.00000	130.85	-3.6589	.11879
2	8.5945	929.77	94.283	-.59617	.15679-02
3	72.798	4940.6	37.120	-.29418	.15703-02
4	137.00	6526.7	18.763	.82711-02	-.95727-03
5	201.20	7512.1	7.9873	-.17611	.82803-03
6	216.20	7595.1	3.2630	-.13885	.79035-03
7	269.45	7494.5	-4.8010	-.12609-01	.35774-04
8	472.95	6296.8	-5.4883	.92319-02	-.82040-05
9	787.00	5229.6	-2.1172	.15026-02	-.50542-06
10	1603.2	4227.7	-.67447	.26502-03	-.50521-07
11	2894.1	3690.0	-.24280	.69364-04	-.14443-07
12	4870.2				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R5B-075/101					
1	.00000	.00000	100.13	.00000	.00000
2	15.689	1571.0	100.13	.00000	-.68682
3	15.932	1595.3	100.01	-.49889	.10633-02
4	79.172	6193.8	49.670	-.29716	.10709-02
5	142.41	8417.4	24.935	-.93978-01	-.65284-03
6	205.65	9453.3	5.2163	-.21783	.62876-03
7	211.05	9475.3	2.9187	-.20764	.59102-03
8	404.42	6549.0	-11.085	.13522	-.70743-03
9	481.23	6174.7	-2.8339	-.27789-01	.28957-03
10	516.06	6054.5	-3.7159	.24673-02	-.81669-06
11	1178.9	4437.7	-1.5215	.84332-03	-.21624-06
12	2281.2	3495.6	-.45061	.12820-03	-.95451-08
13	4865.8				
R7A-059/085					
1	.00000	.00000	61.317	-.75276	.11034-01
2	13.697	726.97	46.906	-.29936	.70043-03
3	183.98	3492.3	5.8828	.58451-01	-.58873-03
4	245.28	3937.0	6.4118	-.49821-01	.20156-03
5	322.33	4227.4	2.3242	-.32318-02	-.76586-05
6	482.79	4485.5	.69547	-.69186-02	.12387-04
7	621.89	4481.7	-.51023	-.17495-02	.23824-05
8	818.98	4331.4	-.92221	-.34082-03	.92509-06
9	1100.1	4065.8	-.89448	.43947-03	-.99384-07
10	2114.6	3506.9	-.30965	.13700-03	-.31221-07
11	3705.6	3235.3	-.11079	-.12014-04	.43202-07
12	4862.3				
R7B-126/152					
1	.00000	.00000	41.102	-.88931-01	-.21353-02
2	24.060	907.70	33.114	-.24306	.64817-03
3	156.87	2536.7	2.8504	.15197-01	-.12781-03
4	236.56	2795.7	2.8375	-.15358-01	.32428-04
5	369.38	2977.6	.47408	-.24374-02	-.38662-05
6	512.47	2984.2	-.46100	-.40971-02	.13948-04
7	624.93	2900.4	-.85332	.60855-03	.64233-07
8	862.84	2732.7	-.55286	.65439-03	-.29936-06
9	1550.9	2564.6	-.77511-01	.36465-04	.22129-06
10	1813.6	2550.7	-.12534-01	.21087-03	-.40746-06
11	2001.3	2553.1	.23562-01	-.18507-04	.60360-08
12	4862.4				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
RSA-133/159					
1	.00000	.00000	56.513	-1.0002	.16221-01
2	15.304	688.77	37.297	-.25542	.67732-03
3	125.06	2601.0	5.7078	-.32395-01	.72840-04
4	234.82	2933.6	1.2290	-.84113-02	.15380-04
5	395.06	2977.8	-.28198	-.10177-02	-.16513-05
6	470.79	2949.9	-.46454	-.13929-02	.37429-05
7	637.63	2851.0	-.61677	.48041-03	-.21006-06
8	805.16	2760.2	-.47348	.37483-03	-.13365-06
9	1581.1	2556.0	-.13319	.63701-04	.54379-07
10	1939.1	2519.0	-.66673-01	.12210-03	-.77606-07
11	2342.6	2506.9	-.60458-02	.28156-04	-.91061-08
12	4856.7				
RSB-162/189					
1	.00000	.00000	36.944	-.74627-01	-.27645-03
2	62.633	1953.2	24.342	-.12657	.28017-03
3	186.47	3558.7	5.8837	-.22487-01	.23542-04
4	260.77	3881.4	2.9320	-.17240-01	.40878-04
5	354.88	4038.7	.77323	-.56983-02	.61968-05
6	596.62	3980.2	-.89536	-.12042-02	.44368-05
7	741.35	3838.8	-.96511	.72227-03	-.61912-06
8	897.17	3703.6	-.78512	.43286-03	-.18074-06
9	1539.4	3330.0	-.45276	.84620-04	.56015-06
10	1784.7	3232.4	-.31020	.49672-03	-.94237-06
11	1959.8	3188.2	-.22293	.15090-05	.11512-07
12	4812.9				
R3D-095/122					
1	.00000	.00000	22.183	.00000	.00000
2	48.204	1069.3	22.183	.00000	-.18437-01
3	50.073	1110.6	21.990	-.10336	.22265-03
4	162.96	2596.1	7.1652	-.27958-01	.47077-04
5	275.85	3116.5	2.6527	-.12015-01	.20891-04
6	427.81	3315.4	.44831	-.24914-02	-.19154-04
7	486.41	3329.3	-.41051-01	-.58590-02	.25481-04
8	545.80	3311.5	-.46735	-.13189-02	.19031-05
9	793.63	3143.6	-.77043	.96024-04	.35908-06
10	1248.4	2846.9	-.46032	.58595-03	-.16250-05
11	1324.2	2814.7	-.39947	.21616-03	-.46374-07
12	2782.6	2548.0	-.64862-01	.13277-04	.10146-07
13	4879.4				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
-----	------	------	------	------	------
R3D-159/186					
1	.00000	.00000	33.659	.00000	.00000
2	14.262	480.06	33.659	.00000	-.46272-01
3	16.290	547.94	33.088	-.28155	.90579-03
4	115.73	1944.9	3.9646	-.11339-01	.12804-04
5	352.17	2417.6	.75023	-.22564-02	.25250-05
6	668.15	2509.1	.80609-01	.13726-03	-.14035-05
7	940.63	2512.8	-.15720	-.10100-02	.22480-04
8	1003.6	2504.5	-.16789-01	.32387-02	-.29030-04
9	1048.2	2507.6	.98935-01	-.64084-03	.14536-05
10	1175.9	2512.8	.63763-02	-.83947-04	.65078-07
11	2026.1	2497.6	.47634-02	.82045-04	-.24927-06
12	2168.5	2499.2	.12965-01	-.24461-04	.70520-08
13	4500.0				
R5C-039/066					
1	.00000	.00000	86.520	-.27203	-.48751-02
2	26.501	2011.1	61.831	-.65961	.23107-02
3	140.92	3911.7	1.6412	.13356	-.95745-03
4	209.57	4344.0	6.4419	-.63632-01	.25588-03
5	296.53	4591.3	1.1800	.31209-02	-.35330-04
6	431.56	4720.5	.90296-01	-.11191-01	.65170-04
7	479.26	4706.5	-.53249	-.18653-02	.20462-05
8	841.43	4366.1	-1.0784	.35790-03	.48257-06
9	1115.2	4107.6	-.77390	.75428-03	-.38565-05
10	1194.7	4048.9	-.72707	-.16487-03	.67430-06
11	1415.6	3887.5	-.70119	.28205-03	-.41697-07
12	4887.6				
R5D-159/186					
1	.00000	.00000	26.638	.00000	.00000
2	29.842	794.93	26.638	.00000	-.74732-03
3	76.139	1954.1	21.833	-.10380	.21364-03
4	253.71	3754.1	5.1785	.10007-01	-.14525-03
5	350.31	4216.8	3.0456	-.32087-01	.20011-03
6	422.05	4344.1	1.5316	.10986-01	-.15511-03
7	462.11	4413.1	1.6651	-.76528-02	.74477-05
8	822.93	4367.4	-.94857	.40920-03	-.58576-06
9	1209.0	4028.5	-.89453	-.26920-03	.18124-05
10	1363.2	3890.8	-.84821	.56949-03	-.21582-06
11	2240.8	3439.1	-.34729	.13192-05	.79522-08
12	3100.6	3146.6	-.32739	.21831-04	.58673-07
13	4829.0				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R6C-166/193					
1	.00000	.00000	39.467	.00000	.00000
2	9.4750	373.95	39.467	.00000	-.14988-01
3	16.920	661.60	36.974	-.33476	.12185-02
4	99.915	2121.0	6.5880	-.31367-01	.60977-04
5	182.91	2486.6	2.6416	-.16184-01	.44852-04
6	263.78	2618.1	.90391	-.53022-02	-.75598-05
7	338.29	2652.9	-.12129-01	-.69922-02	.78042-04
8	365.56	2648.9	-.21938	-.60696-03	.10423-05
9	815.01	2522.4	-.13330	.79854-03	-.74175-05
10	875.55	2515.6	-.11816	-.54837-03	.56727-05
11	935.99	2507.7	-.12227	.48033-03	-.28858-06
12	1504.1	2540.3	.14408	-.11523-04	-.35442-08
13	4888.5				
R8C-048/075					
1	.00000	.00000	62.839	-1.8539	.91190-01
2	5.2510	292.05	50.912	-.41743	.12498-02
3	120.34	2527.6	4.4912	.14096-01	-.25912-03
4	197.35	2838.8	2.0523	-.45767-01	.32361-03
5	241.48	2868.0	-.96387-01	-.29215-02	.42511-05
6	480.98	2735.8	-.76426	.13281-03	.19035-06
7	1172.7	2333.6	-.30728	.52782-03	-.51457-06
8	1601.0	2258.4	-.13832	-.13333-03	.43075-06
9	2057.9	2208.5	.96271-02	.45713-03	-.58878-06
10	2886.4	2195.4	-.44523	-.10062-02	.55098-05
11	2992.5	2143.4	-.47267	.74761-03	-.29289-06
12	4885.4				
R8D-236/263					
1	.00000	.00000	55.428	.00000	.00000
2	15.315	848.86	55.428	.00000	-.38184
3	15.685	869.40	55.271	-.42487	.14954-02
4	82.805	3117.3	18.447	-.12375	.30903-03
5	193.03	4060.9	2.4300	-.21564-01	.15101-04
6	257.68	4132.0	-.16903	-.18635-01	.79298-04
7	318.64	4070.4	-1.5569	-.41332-02	.20160-04
8	426.04	3880.5	-1.7471	.23620-02	-.14759-05
9	724.05	3530.5	-.73259	.10425-02	-.79003-06
10	1074.8	3367.7	-.29290	.21118-03	-.38510-07
11	1734.2	3255.4	-.64636-01	.13500-03	-.13994-06
12	1860.4	3249.1	-.37238-01	.81988-04	-.19927-07
13	4881.4				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R1A-226/252					
1	.00000	.00000	161.61	-38.971	4.5129
2	2.8505	248.53	49.441	-.37886	.10141-02
3	65.170	2103.7	14.034	-.18927	.10171-02
4	127.49	2489.4	2.2941	.88252-03	-.13964-03
5	189.81	2602.0	.77708	-.25224-01	.65241-04
6	204.81	2608.2	.64411-01	-.22287-01	.65945-04
7	334.32	2386.0	-2.3902	.33336-02	-.20659-05
8	694.06	1861.3	-.79385	.11040-02	-.88292-06
9	1053.8	1677.5	-.34231	.15116-03	-.85178-08
10	1479.9	1558.5	-.21811	.14028-03	-.70973-07
11	1845.1	1494.1	-.14406	.62519-04	-.67951-08
12	4865.4				
R1A-399/425					
1	.00000	.00000	132.75	-27.033	3.5769
2	2.4554	215.93	64.693	-.68551	.24748-02
3	98.589	2298.5	1.5054	.28218-01	-.19623-03
4	194.72	2529.7	1.4903	-.28375-01	.15143-03
5	252.40	2550.3	-.27164	-.21714-02	.30822-05
6	483.14	2409.9	-.78139	-.37833-04	.82827-06
7	749.07	2215.0	-.62579	.62294-03	-.82938-06
8	904.72	2129.6	-.49215	.23565-03	-.11129-06
9	1514.3	1891.9	-.32891	.32151-04	.40647-06
10	1799.4	1810.2	-.21144	.37984-03	-.57432-06
11	2003.1	1778.0	-.12819	.28937-04	-.27233-08
12	4883.7				
R2A-205/230					
1	.00000	.00000	73.431	.00000	.00000
2	2.3976	176.06	73.431	.00000	-.47598-01
3	7.1524	520.09	70.202	-.67895	.25157-02
4	98.954	3189.2	9.1471	.13874-01	-.13573-03
5	175.28	3907.8	8.8929	-.17204-01	-.18619-05
6	344.12	4909.8	2.9239	-.18148-01	.42617-04
7	389.70	5009.5	1.5352	-.12320-01	.13620-04
8	672.05	4767.3	-2.1647	-.78390-03	.79405-05
9	744.35	4609.7	-2.1536	.93845-03	-.37983-07
10	1014.5	4095.6	-1.6548	.90767-03	-.27761-06
11	1944.2	3118.6	-.68688	.13343-03	.15897-05
12	2104.4	3018.6	-.52176	.89740-03	-.14140-05
13	2900.0				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R2A-314/339					
1	.00000	.00000	54.240	.00000	.00000
2	.52849	28.666	54.240	.00000	-.22700-01
3	4.7632	256.63	53.019	-.28838	.56587-03
4	88.050	2998.9	16.758	-.14699	.56665-03
5	171.34	3702.4	4.0647	-.54109-02	-.13357-03
6	254.62	3926.2	.38378	-.38784-01	.15931-03
7	318.14	3834.9	-2.6151	-.84277-02	.23156-04
8	535.42	3106.4	-2.9978	.66660-02	-.78359-05
9	804.07	2630.2	1.1128	.35062-03	.18968-05
10	1114.3	2375.3	-.34767	.21159-02	-.15009-04
11	1160.0	2362.4	-.24832	.57289-04	.55149-08
12	2253.0	2166.6	-.10332	.75372-04	-.23203-07
13	4856.3				
R2B-408/434					
1	.00000	.00000	58.555	-.50687	.51581-02
2	13.288	700.68	47.817	-.30124	.67532-03
3	191.64	3477.7	4.8061	.60085-01	-.94559-03
4	222.56	3655.8	5.8097	-.27625-01	.58294-04
5	361.59	4086.3	1.5087	-.33100-02	.28271-06
6	523.03	4244.7	.46206	-.31731-02	.28224-05
7	975.26	4065.8	-.67624	.65611-03	-.11711-05
8	1202.7	3932.2	-.55952	-.14283-03	.48731-06
9	1647.7	3697.8	-.39715	.50771-03	-.64707-06
10	1921.3	3613.9	-.26465	-.23507-04	.73349-07
11	2471.7	3473.4	-.22386	.97606-04	-.20701-07
12	4855.5				
R2B-468/494					
1	.00000	.00000	67.073	-1.3423	.26930-01
2	12.311	672.52	46.267	-.34778	.94610-03
3	134.72	2860.2	3.6529	-.35510-03	-.50763-04
4	257.12	3208.9	1.2842	-.18996-01	.12543-03
5	301.19	3239.3	.34066	-.24145-02	.23575-05
6	600.75	3188.1	-.47128	-.29593-03	.64714-06
7	910.07	3033.1	-.46860	.30460-03	-.55541-06
8	1200.5	2909.1	-.43220	-.17925-03	.76553-06
9	1443.5	2804.5	-.38367	.37895-03	-.65630-06
10	1568.2	2761.3	-.31978	.13344-03	-.22924-07
11	3150.2	2498.6	-.69677-01	.24643-04	-.51972-08
12	4869.2				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R3A-220/245					
1	.00000	.00000	22.971	.00000	.00000
2	54.161	1244.1	22.971	.00000	-.49775-02
3	61.921	1420.1	22.072	-.11588	.25145-03
4	163.92	2732.6	6.2802	-.38937-01	.95300-04
5	265.92	3069.2	1.3115	-.97753-02	.11740-04
6	367.92	3113.7	-.31624	-.61818-02	.33182-04
7	382.92	3107.7	-.47929	-.46876-02	.32371-04
8	423.74	3082.5	-.70018	-.72314-03	.11939-05
9	797.81	2781.9	-.73999	.61672-03	-.55739-06
10	938.06	2688.7	-.59989	.38220-03	-.11021-06
11	2067.0	2340.0	-.15830	.89752-05	.38591-06
12	2136.9	2329.2	-.15140	.89871-04	-.18373-07
13	4819.7				
R3A-430/456					
1	.00000	.00000	131.30	-10.055	.48326
2	6.6034	567.73	61.723	-.48145	.12591-02
3	151.53	3233.5	1.5096	.65976-01	-.42889-03
4	238.49	3581.6	3.2546	-.45908-01	.23941-03
5	316.98	3670.0	.47305	.10473-01	-.60824-04
6	426.05	3767.3	.58696	-.94285-02	.25024-04
7	544.03	3746.4	-.59285	-.57129-03	.51750-06
8	1188.7	3265.4	-.68421	.42958-03	-.16478-06
9	1961.1	2917.3	-.31551	.47740-04	.11396-06
10	2498.3	2779.2	-.16558	.23138-03	-.19059-06
11	3037.4	2727.3	-.82289-01	-.76886-04	.54802-07
12	4870.4				
R3B-363/389					
1	.00000	.00000	62.641	-.21209	-.20207-02
2	21.752	1241.4	50.545	-.34395	.84828-03
3	163.52	3911.3	4.1693	.16814-01	-.14074-03
4	248.57	4301.0	3.9750	-.19099-01	.37703-04
5	390.34	4588.1	.83298	-.30646-02	-.47997-05
6	480.79	4634.8	.16074	-.43670-02	.49151-05
7	799.04	4402.1	-1.1254	.32564-03	-.38249-06
8	1099.3	4083.1	-1.0333	-.18952-04	.26518-05
9	1197.8	3983.7	-.95995	.76433-03	-.53501-06
10	1501.9	3747.4	-.64349	.27618-03	-.51768-07
11	3147.4	3205.7	-.15507	.20640-04	.76879-08
12	4868.7				

R4A-426/452

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
1	.00000	.00000	82.999	-2.6393	.12191
2	5.6948	409.58	64.799	-.55657	.18347-02
3	104.39	3147.3	8.5524	-.13338-01	-.58500-04
4	203.08	3805.2	4.2102	-.30659-01	.71266-04
5	298.36	3989.7	.30884	-.10288-01	.15207-04
6	383.40	3950.9	-1.1110	-.64090-02	.19248-04
7	483.33	3795.1	-1.8153	-.63863-03	.24161-05
8	893.57	3109.7	-1.1194	.23350-02	-.37119-05
9	1112.2	2937.8	-.63069	-.994[illegible]3-04	.51752-06
10	1449.2	2733.8	-.52139	.42378-03	-.26093-06
11	1865.2	2571.4	-.30427	.98131-04	-.13124-07
12	4869.8				

R4B-391/417

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
1	.00000	.00000	88.928	-1.5957	.27956-01
2	11.652	863.76	63.129	-.61848	.21817-02
3	109.83	3164.8	4.7761	.24108-01	-.30131-03
4	168.73	3468.2	4.4798	-.29139-01	.50590-04
5	368.24	3603.9	-1.1059	.11406-02	-.95324-05
6	461.33	3503.2	-1.1414	-.15215-02	.36719-05
7	671.55	3230.1	-1.2943	.79424-03	.20849-06
8	1000.3	2897.9	-.70451	.99985-03	-.17381-05
9	1110.6	2830.0	-.54738	.42471-03	-.25591-06
10	1739.4	2590.1	-.31682	-.58091-04	.50530-06
11	1859.8	2552.0	-.30883	.12443-03	-.11995-07
12	4858.4				

R4B-449/475

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
1	.00000	.00000	35.391	.00000	.00000
2	8.9685	317.40	35.391	.00000	-.39764-02
3	26.944	930.47	31.537	-.21443	.58163-03
4	138.07	2585.1	5.4261	-.20535-01	.27928-04
5	249.19	2972.8	1.8969	-.11224-01	.13688-04
6	360.31	3063.8	-.90580-01	-.66604-02	.22257-04
7	375.31	3061.0	-.27537	-.56579-02	.22800-04
8	455.91	3014.0	-.74306	-.14506-03	-.40655-06
9	679.79	2835.8	-.86914	-.41812-03	.12476-05
10	1068.0	2508.4	-.62975	.10348-02	-.10500-05
11	1391.5	2377.4	-.28989	.15747-04	.79055-07
12	1981.3	2228.2	-.18881	.15563-03	-.41091-07
13	4859.1				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R5A-397/423					
1	.00000	.00000	16.918	.00000	.00000
2	110.89	1876.0	16.918	.00000	-.93813-02
3	114.21	1931.9	16.607	-.93504-01	.29217-03
4	212.16	2936.0	6.6991	-.76507-02	-.86564-05
5	310.11	3510.7	4.9512	-.10194-01	-.49847-04
6	408.06	3851.0	1.5195	-.24842-01	.16619-03
7	446.77	3882.2	.34338	-.55440-02	.95094-05
8	679.73	3781.5	-.69141	.11021-02	-.11184-05
9	1146.8	3585.1	-.39385	-.46502-03	.11855-05
10	1299.8	3518.2	-.45291	.78950-04	.60828-08
11	3443.3	2970.0	-.30595-01	.11804-03	-.19923-05
12	3533.8	2966.8	-.58221-01	-.42317-03	.35167-06
13	4803.2				
R5A-442/468					
1	.00000	.00000	78.370	.00000	.00000
2	1.6003	125.41	78.370	.00000	-.10492-01
3	15.865	1212.9	71.965	-.44898	.10104-02
4	91.988	4535.0	21.173	-.21825	.10102-02
5	168.11	5327.7	5.5079	.12458-01	-.35658-03
6	244.24	5661.9	1.2058	-.68977-01	.34886-03
7	259.24	5665.7	-.62804	-.53281-01	.36435-03
8	306.07	5556.8	-3.2212	-.20911-02	.59363-05
9	592.60	4601.8	-2.9574	.30118-02	-.15291-05
10	1075.5	3703.9	-1.1183	.79667-03	-.31169-06
11	1671.2	3254.5	-.50096	.23962-03	-.83824-07
12	2360.2	2995.7	-.29016	.66370-04	-.58859-08
13	4866.1				
R5A-504/530					
1	.00000	.00000	29.206	-.30807-01	-.24715-03
2	69.164	1790.9	21.398	-.82088-01	.12440-03
3	251.88	3719.0	3.8602	-.13896-01	-.54827-05
4	354.99	3963.3	.82000	-.15592-01	.10032-03
5	441.77	3982.6	.38050	.10527-01	-.18165-03
6	487.75	4004.7	.19638	-.14531-01	.52961-04
7	581.50	3939.1	-1.1318	.36343-03	-.23075-06
8	871.46	3635.8	-.97927	.16271-03	.51253-06
9	1161.4	3378.0	-.75563	.60855-03	-.29334-06
10	1568.7	3151.4	-.40591	.25013-03	-.16699-06
11	1810.9	3065.4	-.31413	.12878-03	-.19650-07
12	4788.1				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R5B-341/367					
1	.00000	.00000	58.945	-.42116	.11989-02
2	15.141	800.11	47.016	-.36670	.11987-02
3	114.10	3023.4	9.6553	-.10817-01	-.86757-04
4	169.22	3508.1	7.6725	-.25161-01	.41150-04
5	311.97	4210.4	3.0045	-.75377-02	.28917-05
6	461.25	4500.5	.94745	-.62427-02	.84935-05
7	678.36	4498.9	-.56218	-.71073-03	.75571-06
8	1141.6	4161.1	-.73417	.33944-03	-.12060-06
9	1951.9	3724.9	-.42161	.46262-04	.17924-06
10	2398.5	3561.8	-.27308	.28637-03	-.23566-06
11	2850.8	3475.0	-.15866	-.33436-04	.54846-07
12	4129.7				
R5B-398/423					
1	.00000	.00000	43.200	-.30251	.14862-02
2	39.150	1316.8	26.347	-.12796	.26838-03
3	157.50	3087.6	7.3371	-.32667-01	.54310-04
4	323.19	3653.5	.98497	-.56707-02	-.26013-05
5	394.20	3693.9	.14026	-.62248-02	.45110-04
6	429.74	3693.1	-.13127	-.14149-02	.19269-05
7	722.78	3581.6	-.46413	.27903-03	-.90364-07
8	1229.1	3406.4	-.25106	.14176-03	-.34501-06
9	1503.4	3341.1	-.25117	-.14214-03	.44013-06
10	1749.6	3277.2	-.24114	.18287-03	-.31029-06
11	1925.4	3238.8	-.20561	.19201-04	.24410-08
12	4789.5				
R7A-263/289					
1	.00000	.00000	29.412	-.37154	.34794-02
2	9.7146	253.86	23.179	-.27014	.97247-03
3	62.418	867.47	2.8081	-.11638	.97137-03
4	115.12	834.40	-1.3647	.37204-01	-.26158-03
5	167.82	827.52	.37706	-.41551-02	.98896-05
6	182.82	832.28	.25908	-.37100-02	.98488-05
7	313.67	824.72	-.20593	.15615-03	-.56076-07
8	677.14	767.81	-.11465	.95002-04	-.21198-07
9	1293.0	728.29	-.21748-01	.55834-04	-.34070-06
10	1404.1	726.09	-.21954-01	-.57690-04	.71333-07
11	1838.4	711.52	-.31702-01	.35244-04	-.69745-08
12	4863.1				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
-----	------	------	------	------	------
R7A-342/368					
1	.00000	.00000	68.058	.00000	.00000
2	17.127	1165.7	68.058	.00000	-.29432-02
3	53.131	3478.6	56.613	-.31789	.63570-03
4	107.63	5722.7	27.627	-.21396	.63232-03
5	162.13	6695.2	9.9402	-.11057	.22214-03
6	216.63	6944.5	-.13272	-.74252-01	-.17615-03
7	269.35	6705.3	-9.4310	-.10211	.46279-03
8	389.82	4896.3	-13.885	.65144-01	-.14693-03
9	524.84	3847.6	-4.3287	.56332-02	-.31676-05
10	842.23	2939.9	-1.7101	.26171-02	-.24086-05
11	1130.7	2606.6	-.80149	.53309-03	-.17855-06
12	1715.5	2284.4	-.36116	.21982-03	-.45064-07
13	4837.2				
R7B-241/267					
1	.00000	.00000	23.260	-.29513-01	-.17277-03
2	93.963	1781.7	13.137	-.78215-01	.19375-03
3	212.46	2562.5	2.7625	-.93363-02	.11723-04
4	354.01	2799.7	.82410	-.43584-02	-.83465-06
5	487.52	2830.1	-.38435	-.46928-02	.20790-04
6	544.61	2796.7	-.71689	-.11323-02	.22121-05
7	773.79	2599.6	-.88734	.38859-03	.17427-06
8	1167.7	2321.0	-.50009	.59452-03	-.98958-06
9	1276.2	2272.5	-.40603	.27239-03	-.72596-07
10	2277.7	2066.1	-.78867-01	.54268-04	-.16542-07
11	3147.1	2027.7	-.22018-01	.11124-04	.35504-08
12	4868.4				
R8A-164/190					
1	.00000	.00000	48.686	-.23332-01	-.55589-02
2	15.243	717.00	44.100	-.27753	.61840-03
3	84.756	2649.2	14.480	-.14857	.61886-03
4	154.27	3145.7	2.7959	-.19515-01	.27625-04
5	223.78	3255.0	.48322	-.13754-01	.32150-04
6	238.78	3259.3	.92297-01	-.12307-01	.32202-04
7	365.43	3139.0	-1.4755	-.71839-04	.12319-05
8	717.24	2664.7	-1.0686	.12284-02	-.62933-06
9	1157.2	2378.7	-.35321	.39767-03	-.20150-06
10	1687.9	2273.1	-.10138	.76920-04	-.23756-07
11	3138.6	2215.4	-.28192-01	-.26474-04	.33286-07
12	4849.9				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
-----	------	------	------	------	------
R8A-432/458					
1	.00000	.00000	108.82	.00000	.00000
2	21.250	2312.4	108.82	.00000	-.22753
3	22.453	2442.9	107.83	-.82121	.24921-02
4	68.163	5893.9	48.374	-.47947	.25127-02
5	113.87	7343.2	20.291	-.13490	-.72110-03
6	159.58	7920.0	3.4383	-.23378	.73523-03
7	174.58	7921.4	-3.0789	-.20070	.72680-03
8	305.31	5712.8	-18.291	.84331-01	-.17507-03
9	449.64	4303.3	-4.8884	.85290-02	-.68764-05
10	783.79	3365.6	-1.4918	.16357-02	-.87756-06
11	1232.7	2946.1	-.55374	.45375-03	-.12958-06
12	2605.4	2705.8	-.40532-01	-.79873-04	.22735-07
13	4841.9				
R8B-333/359					
1	.00000	.00000	117.60	-27.539	4.4957
2	2.0145	161.90	61.380	-.36885	.88088-03
3	105.98	3546.4	13.247	-.94098-01	.24073-03
4	209.95	4177.1	1.4872	-.19011-01	.36928-04
5	366.19	4086.2	-1.7490	-.17023-02	.97734-05
6	444.59	3943.3	-1.8357	.59647-03	.20114-05
7	618.10	3653.3	-1.4471	.16434-02	-.17469-05
8	784.10	3450.3	-1.0459	.77347-03	-.29090-06
9	1424.6	3021.3	-.41308	.21450-03	-.70041-07
10	2259.9	2785.1	-.20134	.38983-04	.16100-07
11	3148.3	2648.3	-.93956-01	.81892-04	-.33686-07
12	4867.1				
R8B-515/541					
1	.00000	.00000	56.429	-.32835	.88599-03
2	8.6729	465.28	50.933	-.30530	.69982-03
3	146.38	3517.1	6.6622	-.16195-01	-.11642-04
4	195.95	3806.2	4.9707	-.17927-01	.19945-04
5	472.98	4231.4	-.36977	-.13510-02	-.80291-05
6	549.77	4191.5	-.71930	-.32008-02	.79988-05
7	719.25	4016.5	-1.1150	.86610-03	-.16248-05
8	861.57	3870.7	-.96719	.17241-03	.25828-06
9	1315.5	3491.4	-.65103	.52411-03	-.66025-06
10	1486.7	3391.9	-.52961	.18486-03	-.28112-07
11	3180.8	2888.6	-.14531	.41991-04	-.10039-07
12	4954.2				

R3C-296/323

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
1	.00000	.00000	51.827	.00000	.00000
2	10.517	545.09	51.827	.00000	-.22955-01
3	17.438	896.13	48.529	-.47655	.17840-02
4	102.89	2676.4	6.1649	-.19199-01	.29055-04
5	277.00	3321.2	2.1217	-.40226-02	.17248-05
6	610.61	3645.3	.13639-01	-.22964-02	.96069-05
7	715.49	3632.6	-.15105	.72614-03	-.61095-05
8	832.58	3615.0	-.23231	-.14201-02	-.25580-04
9	920.64	3566.1	-1.0775	-.81775-02	.14142-02
10	933.45	3553.9	-.59158	.46135-01	-.79690-03
11	956.46	3555.0	.26563	-.88925-02	.33008-04
12	1087.6	3511.4	-.36344	.40969-02	-.32456-04
13	1230.6				

R3C-380/407

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
1	.00000	.00000	34.885	.00000	.00000
2	1.8868	65.822	34.885	.00000	-.23608-02
3	31.643	1041.7	28.614	-.21074	.51778-03
4	101.04	2185.5	6.8460	-.10295	.51891-03
5	170.43	2338.2	.54126-01	.50774-02	-.98485-04
6	239.82	2333.5	-.66397	-.15425-01	.79114-04
7	323.46	2216.4	-1.5841	.44236-02	-.26374-04
8	374.95	2143.0	-1.3383	.34939-03	.15962-05
9	643.13	1840.0	-.80649	.16335-02	-.23484-05
10	813.87	1738.2	-.45406	.43063-03	-.12290-06
11	2624.7	1598.3	-.10345	-.23702-03	.77248-06
12	2835.3	1573.2	-.10050	.25103-03	-.10957-06
13	4875.5				

R3D-219/246

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
1	.00000	.00000	39.695	.00000	.00000
2	8.2436	327.23	39.695	.00000	-.44569-01
3	9.9649	395.33	39.299	-.23015	.51320-03
4	144.65	2767.2	5.2318	-.22796-01	.32323-04
5	369.16	3158.5	-.11651	-.10257-02	-.25856-05
6	527.72	3103.9	-.63680	-.22556-02	-.76078-05
7	575.66	3067.4	-.90554	-.33501-02	.42343-04
8	606.65	3037.4	-.99118	.58620-03	-.10573-06
9	1107.0	2674.9	-.48393	.42747-03	-.65997-06
10	1203.1	2631.8	-.42007	.23727-03	-.68784-07
11	2267.0	2370.6	-.14878	.17742-04	.28247-06
12	2429.0	2348.2	-.12079	.15503-03	-.48149-07
13	4875.5				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R3D-287/314					
1	.00000	.00000	41.185	.00000	.00000
2	5.9434	244.78	41.185	.00000	-.49241-02
3	19.281	782.41	38.558	-.19703	.38338-03
4	177.72	3470.3	4.9954	-.14798-01	.19878-04
5	349.67	3992.8	1.6697	-.45443-02	.41849-05
6	594.95	4190.7	.19573	-.14648-02	-.25142-06
7	715.08	4192.6	-.16710	-.15555-02	.54699-05
8	817.41	4165.1	-.31361	.12369-03	-.98346-06
9	1087.3	4070.1	-.46182	-.67273-03	.24256-05
10	1236.4	3994.3	-.50067	.41214-03	-.21333-05
11	1353.3	3938.0	-.49177	-.33600-03	.10484-05
12	1499.6	3862.2	-.52277	.12406-03	-.93601-08
13	4882.7				
R5C-219/246					
1	.00000	.00000	31.177	.00000	.00000
2	14.025	437.26	31.177	.00000	-.20926-02
3	37.852	1151.8	27.613	-.14958	.34479-03
4	159.35	2917.1	6.5349	-.23904-01	.37961-04
5	294.95	3458.3	2.1461	-.84620-02	.11686-04
6	436.36	3625.7	.45395	-.35044-02	-.10568-04
7	487.37	3638.3	.13898-01	-.51218-02	.12967-04
8	606.53	3589.2	-.65438	-.48656-03	.98411-06
9	900.20	3380.0	-.68554	.38046-03	-.27935-06
10	1425.6	3084.3	-.51710	-.59873-04	.10191-05
11	1751.8	2944.6	-.23097	.93721-03	-.30815-05
12	1866.2	2925.8	-.13752	-.12041-03	.40598-07
13	4726.3				
R5C-282/309					
1	.00000	.00000	37.118	.00000	.00000
2	.66436-01	2.4659	37.118	.00000	-.34947-02
3	20.017	715.22	32.945	-.20916	.51131-03
4	156.84	2616.9	4.4247	.71159-03	-.67793-04
5	238.93	2947.4	3.1710	-.15984-01	.38846-04
6	342.91	3148.0	1.1069	-.38660-02	.18155-05
7	460.48	3227.6	.27320	-.32257-02	.32488-05
8	670.98	3172.5	-.65295	-.11740-02	.67485-05
9	743.62	3121.5	-.71668	.29665-03	-.10430-06
10	1359.1	2768.5	-.47004	.10408-03	.18270-06
11	1770.1	2605.5	-.29188	.32936-03	-.17641-06
12	2485.4	2500.7	-.91478-01	-.49198-04	.30818-07
13	4882.3				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R5D-225/252					
1	.00000	.00000	48.599	.00000	.00000
2	6.2090	301.75	48.599	.00000	-.83347-02
3	17.988	860.55	45.130	-.29451	.79044-03
4	138.54	3405.8	8.5838	-.86324-02	-.77047-04
5	206.01	3922.0	6.3668	-.24227-01	.42497-04
6	344.27	4451.5	2.1047	-.66011-02	-.34976-06
7	447.62	4598.1	.72904	-.67095-02	.94104-05
8	670.69	4531.3	-.85956	-.41190-03	.38311-06
9	1155.0	4061.9	-.98895	.14474-03	.40587-06
10	1569.6	3705.7	-.65968	.64952-03	-.47077-06
11	2294.1	3389.7	-.45984	-.37369-03	.46339-06
12	2856.3	3095.4	-.44060	.40792-03	-.11604-06
13	4887.1				
R5D-294/321					
1	.00000	.00000	57.875	-3.2210	.75829
2	1.2589	69.268	53.371	-.35716	.97401-03
3	109.61	2898.1	10.279	-.40535-01	.73863-04
4	246.87	3736.2	3.3261	-.10121-01	.96666-05
5	427.46	4063.7	.61615	-.48843-02	.61406-05
6	590.56	4060.9	-.48706	-.18797-02	.39145-05
7	734.52	3963.6	-.78489	-.18917-03	-.34075-06
8	899.73	3827.2	-.87530	-.35805-03	.12229-05
9	1153.0	3602.4	-.82139	.57096-03	-.33720-06
10	1817.3	3209.9	-.50923	-.10108-03	.20613-06
11	2539.4	2867.1	-.33278	.34545-03	-.12292-06
12	4884.5				
R6A-562/589					
1	.00000	.00000	41.124	.00000	.00000
2	3.3770	138.87	41.124	.00000	-.15705
3	4.0024	164.56	40.939	-.29470	.80127-03
4	123.29	2214.8	4.8370	-.79465-02	-.73314-04
5	170.23	2416.7	3.6067	-.18269-01	.48043-04
6	257.67	2624.5	1.5137	-.56666-02	.67299-05
7	547.35	2751.1	-.75064-01	.18197-03	-.31448-05
8	738.56	2721.4	-.35043	-.16221-02	.78564-05
9	819.93	2686.4	-.45835	.29586-03	-.12598-06
10	2009.2	2347.9	-.28917	-.15360-03	.63680-06
11	2448.1	2245.2	-.55963-01	.68491-03	-.12277-05
12	2709.8	2255.5	.50286-01	-.27890-03	.13274-06
13	4883.2				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R6C-529/556					
1	.00000	.00000	130.60	-30.677	6.1511
2	1.6161	156.90	79.642	-.85444	.34125-02
3	83.480	2822.7	8.3550	-.16355-01	.15118-04
4	315.21	4068.7	3.2103	-.58456-02	.15378-06
5	368.27	4222.6	2.5913	-.58210-02	.45930-05
6	755.55	4619.9	.14928	-.48486-03	-.13462-04
7	790.19	4623.9	.67221-01	-.18840-02	.25923-05
8	983.37	4585.3	-.37048	-.38177-03	.23110-06
9	2089.3	4021.2	-.36693	.38498-03	-.77988-06
10	2439.5	3906.4	-.38418	-.43425-03	.12723-05
11	2609.6	3834.8	-.42146	.21511-03	-.56545-07
12	4884.5				
R8C-378/405					
1	.00000	.00000	95.787	-.37472	.71710-02
2	11.385	1052.6	90.043	-.12978	-.10839-02
3	78.585	6188.5	57.916	-.34829	.87791-03
4	145.79	8774.0	23.000	-.17130	.41815-03
5	198.50	9571.6	8.4259	-.10518	.36690-04
6	309.12	9266.2	-13.498	-.93003-01	.49100-03
7	427.60	7178.1	-14.859	.81516-01	-.31114-03
8	500.52	6407.4	-7.9344	.13454-01	-.10454-04
9	869.18	4787.0	-2.2767	.18922-02	-.12298-05
10	990.42	4536.6	-1.8721	.14449-02	-.60372-06
11	1771.0	3668.5	-.71999	.31083-04	.32674-07
12	4879.3				
R8C-476/503					
1	.00000	.00000	23.886	.00000	.00000
2	19.802	473.00	23.886	.00000	-.17390-01
3	23.344	556.82	23.231	-.18478	.55046-03
4	77.897	1363.6	7.9857	-.94688-01	.55136-03
5	132.45	1607.0	2.5773	-.44524-02	-.12165-03
6	187.00	1714.6	1.0054	-.24361-01	.13800-03
7	240.15	1719.9	-.41461	-.23592-02	.36836-05
8	552.69	1472.4	-.80986	.10946-02	-.11385-04
9	615.13	1423.3	-.80633	-.10381-02	.45649-05
10	823.63	1251.4	-.64386	.18173-02	-.30245-05
11	1003.1	1176.9	-.28383	.18901-03	-.56532-07
12	1840.9	1038.5	-.86169-01	.46919-04	-.60628-08
13	4652.2				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)

R8D-446/473

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
1	.00000	.00000	47.292	-.24544	-.66712-03
2	15.656	677.67	39.117	-.27677	.71067-03
3	74.202	2161.8	14.017	-.15195	.71174-03
4	132.75	2604.4	3.5434	-.26938-01	.26220-04
5	191.30	2724.8	.65882	-.22333-01	.17313-03
6	221.30	2729.1	-.21369	-.67510-02	.12073-04
7	435.24	2492.6	-1.4446	.99780-03	-.50553-07
8	1013.0	1981.3	-.34215	.91017-03	-.34175-05
9	1130.9	194[illegible].0	-.27003	-.29825-03	.61184-06
10	1419.4	1860.0	-.28934	.23129-03	-.15468-06
11	1813.5	1772.4	-.17911	.48394-04	-.16699-07
12	4302.7				

R8D-534/561

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
1	.00000	.00000	39.234	.00000	.00000
2	25.189	988.28	39.234	.00000	-.14224-01
3	31.839	1245.0	37.347	-.28374	.77433-03
4	84.814	2542.3	13.805	-.16068	.77832-03
5	137.79	2938.4	3.3336	-.36981-01	.11325-03
6	190.76	3028.1	.36893	-.18982-01	.58880-04
7	302.47	2914.5	-1.6678	.74990-03	.10441-05
8	497.59	2625.4	-1.2559	.13611-02	-.10760-05
9	755.65	2373.4	-.76842	.52805-03	-.17597-06
10	1201.0	2120.4	-.40278	.29293-03	-.51253-07
11	1601.7	2002.7	-.19271	.23132-03	-.43691-06
12	1813.8	1968.1	-.15355	-.46669-04	.16972-07
13	4881.8				

R9A-341/368

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
1	.00000	.00000	81.076	-5.2227	.45585
2	3.4471	236.09	61.320	-.50863	.14154-02
3	139.06	2727.9	1.4594	.67223-01	-.57805-03
4	187.88	2892.1	3.8899	-.17439-01	.39748-04
5	323.49	3198.0	1.3529	-.12684-02	-.15182-04
6	428.29	3308.4	.58682	-.60413-02	.12070-04
7	552.97	3311.0	-.35673	-.15266-02	.18426-05
8	865.96	3106.3	-.77084	.20359-03	.16156-06
9	1449.8	2757.8	-.36786	.48659-03	-.76341-06
10	1746.9	2671.4	-.28086	-.19370-03	.57667-06
11	2005.3	2595.9	-.26546	.25332-03	-.78571-07
12	4603.3				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R9B-385/412					
1	.00000	.00000	47.696	.00000	.00000
2	29.801	1421.4	47.696	.00000	-.35397-01
3	34.937	1661.5	44.895	-.54539	.21694-02
4	126.00	2865.3	-.46592	.47244-01	-.34394-03
5	161.00	2892.2	1.5773	.11124-01	-.35814-04
6	344.59	3335.1	2.0405	-.86012-02	.39747-04
7	391.95	3416.6	1.4932	-.29541-02	.11488-05
8	822.14	3603.8	-.41063	-.14722-02	.24884-04
9	839.55	3596.3	-.43926	-.17308-03	.47125-06
10	1286.5	3407.5	-.31161	.45873-03	-.77797-04
11	1311.5	3398.8	-.43446	-.53746-02	.65651-04
12	1339.9	3383.6	-.58085	.23042-03	.12281-06
13	1858.3				
R9C-426/453					
1	.00000	.00000	56.033	.00000	.00000
2	4.6210	258.93	56.033	.00000	-.22735-01
3	10.880	604.06	53.361	-.42690	.11918-02
4	139.63	2941.4	2.7046	.33440-01	-.23051-03
5	216.87	3243.7	3.7444	-.19980-01	.52270-04
6	314.72	3467.7	1.3357	-.46367-02	.71451-06
7	415.12	3555.8	.42632	-.44215-02	.49154-05
8	631.55	3490.8	-.79681	-.12300-02	.32127-05
9	858.60	3284.1	-.85847	.95841-03	-.24070-05
10	967.68	3198.7	-.73530	.17079-03	.28281-06
11	1373.4	2947.4	-.45710	.51498-03	-.78032-06
12	1502.4	2895.3	-.36317	.21291-03	-.37334-07
13	4502.4				
R9D-181/208					
1	.00000	.00000	313.95	-63.984	5.0446
2	4.2060	563.90	43.438	-.33058	.10033-02
3	105.74	2616.4	7.3354	-.24988-01	.27891-05
4	199.15	3085.9	2.7400	-.24207-01	.90024-04
5	246.28	3170.7	1.0582	-.11478-01	.21545-04
6	365.13	3170.4	-.75727	-.37961-02	.73589-05
7	670.88	2794.4	-1.0148	.29538-02	-.84627-05
8	755.43	2724.6	-.69682	.80731-03	-.32810-06
9	1779.0	2505.3	-.75371-01	-.20017-03	.46670-06
10	2212.4	2473.0	.14135-01	.40668-03	-.42282-06
11	2766.6	2533.8	.75315-01	-.29629-03	.19495-06
12	4404.2				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R10A-351/378					
1	.00000	.00000	67.673	-4.1409	.47697
2	2.6651	159.97	55.764	-.32742	.70148-03
3	152.98	3526.8	4.8816	-.11085-01	.98416-05
4	491.92	4291.1	.75912	-.10781-02	-.30481-05
5	724.10	4371.1	-.23451	-.32014-02	.26570-04
6	799.89	4346.5	-.26192	.28396-02	-.10291-04
7	949.04	4336.4	-.10163	-.17648-02	.32255-05
8	1122.6	4282.5	-.42274	-.85164-04	.99780-07
9	1986.3	3918.1	-.34655	.17338-03	-.15064-06
10	2697.5	3705.2	-.32851	-.14802-03	.23703-06
11	3172.4	3541.2	-.30872	.18969-03	-.93351-07
12	4925.1				
R10B-351/378					
1	.00000	.00000	82.678	-10.123	1.1429
2	2.8592	180.35	52.821	-.31979	.74528-03
3	130.49	3262.1	7.6107	-.34426-01	.64158-04
4	258.13	3806.1	1.9583	-.98602-02	.15662-04
5	389.86	3928.8	.17580	-.36705-02	.76778-05
6	556.43	3891.7	-.40791	.16611-03	-.26569-05
7	767.43	3788.0	-.69267	-.15157-02	.63524-05
8	929.34	3663.1	-.68390	.15699-02	-.26929-05
9	1165.5	3553.7	-.39294	-.33775-03	.66661-06
10	1483.2	3416.2	-.40572	.29754-03	-.12808-06
11	2358.4	3203.1	-.17921	-.38767-04	.37964-07
12	4882.6				
R10C-316/343					
1	.00000	.00000	43.436	-.89245	.84128-01
2	2.6540	110.57	40.476	-.22261	.48888-03
3	124.87	2624.8	7.9706	-.43369-01	.86362-04
4	281.51	3141.1	.74090	-.27834-02	-.12174-04
5	411.77	3163.5	-.60382	-.75405-02	.63033-04
6	457.30	3126.3	-.89846	.10693-02	-.55723-05
7	526.12	3067.7	-.83046	-.81287-04	.41342-06
8	1065.6	2661.0	-.55719	.58784-03	-.64139-06
9	1163.4	2611.5	-.46063	.39970-03	-.24058-06
10	1806.3	2416.6	-.24501	-.64324-04	.15597-06
11	2471.9	2271.1	-.12336	.24711-03	-.93598-07
12	4885.2				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R10D-325/352					
1	.00000	.00000	42.859	.00000	.00000
2	25.188	1079.5	42.859	.00000	-.22273-01
3	28.878	1236.6	41.949	-.24655	.64332-03
4	109.81	3357.7	14.683	-.90351-01	.24881-03
5	190.74	4086.1	4.9472	-.29941-01	.55188-04
6	307.67	4343.5	.20910	-.10583-01	.30338-04
7	361.65	4328.7	-.66824	-.56695-02	.16234-04
8	451.61	4234.5	-1.2942	-.12886-02	.34989-05
9	716.26	3866.6	-1.2410	.148[illegible]4-02	-.22098-05
10	864.83	3707.9	-.94478	.50451-03	-.26786-06
11	1361.6	3330.2	-.64183	.10528-03	.38678-07
12	2111.6	2924.4	-.41865	.19230-03	-.32511-07
13	4879.0				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R1C-065/092					
1	.00000	.00000	297.04	-160.77	50.473
2	1.0561	193.84	126.35	-.86019	.22106-02
3	55.909	4901.0	51.933	-.49642	.22211-02
4	110.76	6622.6	17.521	-.13091	.21874-04
5	165.62	7193.4	3.3570	-.12731	.39038-03
6	180.62	7216.5	-.19884	-.10974	.38564-03
7	288.34	6403.7	-10.417	.14884-01	-.62164-05
8	451.53	5073.0	-6.0560	.11840-01	-.10381-04
9	795.08	3969.0	-1.5964	.11406-02	-.34038-06
10	1747.2	3189.2	-.35017	.16827-03	-.73334-07
11	2684.8	2948.4	-.22803	-.37991-04	.36828-07
12	4880.4				
R1D-071/098					
1	.00000	.00000	146.24	-1541.8	17753.
2	.28940-01	3.3710	101.60	-.47240	.82894-03
3	67.136	4944.6	49.397	-.30552	.82606-03
4	134.24	7133.3	19.553	-.13922	.48847-05
5	201.35	7820.0	.93394	-.13823	.37836-03
6	216.35	7804.1	-2.9577	-.12121	.37076-03
7	367.44	5869.1	-14.193	.46847-01	-.60043-04
8	606.35	4333.4	-2.0900	.38112-02	-.61689-05
9	799.11	4028.0	-1.3083	.24384-03	.60214-06
10	1290.5	3515.4	-.63255	.11315-02	-.88733-06
11	1830.3	3364.1	-.18671	-.30559-03	.92701-07
12	4881.2				
R3C-128/155					
1	.00000	.00000	57.441	.00000	.00000
2	16.898	970.62	57.441	.00000	-.95230-02
3	28.200	1606.1	53.791	-.32289	.77521-03
4	144.42	4713.3	10.152	-.52602-01	.94548-04
5	290.66	5368.6	.83259	-.11123-01	.18527-04
6	464.13	5275.0	-1.3540	-.14813-02	-.61926-05
7	595.04	5058.5	-2.0602	-.39132-02	.22514-04
8	754.28	4722.1	-1.5938	.68423-02	-.12387-04
9	984.14	4566.9	-.41170	-.16997-02	.35541-05
10	1232.1	4414.5	-.59912	.94378-03	-.98292-06
11	1480.4	4308.8	-.31222	.21143-03	-.19843-06
12	1780.6	4228.8	-.23893	.32769-04	.19977-08
13	4876.0				

STRAIN RATE = (10E-5)/SEC
TEMPERATURE = -20°C

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R1C-065/092					
1	.00000	.00000	297.04	-160.77	50.473
2	1.0561	193.84	126.35	-.86019	.22106-02
3	55.909	4901.0	51.933	-.49642	.22211-02
4	110.76	6622.6	17.521	-.13091	.21874-04
5	165.62	7193.4	3.3570	-.12731	.39038-03
6	180.62	7216.5	-.19884	-.10974	.38564-03
7	288.34	6403.7	-10.417	.14884-01	-.62164-05
8	451.53	5073.0	-6.0560	.11840-01	-.10381-04
9	795.08	3969.0	-1.5964	.11406-02	-.34038-06
10	1747.2	3189.2	-.35017	.16827-03	-.73334-07
11	2684.8	2948.4	-.22803	-.37991-04	.36828-07
12	4880.4				
R1D-071/098					
1	.00000	.00000	146.24	-1541.8	17753.
2	.28940-01	3.3710	101.60	-.47240	.82894-03
3	67.136	4944.6	49.397	-.30552	.82606-03
4	134.24	7133.3	19.553	-.13922	.48847-05
5	201.35	7820.0	.93394	-.13823	.37836-03
6	216.35	7804.1	-2.9577	-.12121	.37076-03
7	367.44	5869.1	-14.193	.46847-01	-.60043-04
8	606.35	4333.4	-2.0900	.38112-02	-.61689-05
9	799.11	4028.0	-1.3083	.24384-03	.60214-06
10	1290.5	3515.4	-.63255	.11315-02	-.88733-06
11	1830.3	3364.1	-.18671	-.30559-03	.92701-07
12	4881.2				
R3C-128/155					
1	.00000	.00000	57.441	.00000	.00000
2	16.898	970.62	57.441	.00000	-.95230-02
3	28.200	1606.1	53.791	-.32289	.77521-03
4	144.42	4713.3	10.152	-.52602-01	.94548-04
5	290.66	5368.6	.83259	-.11123-01	.18527-04
6	464.13	5275.0	-1.3540	-.14813-02	-.61926-05
7	595.04	5058.5	-2.0602	-.39132-02	.22514-04
8	754.28	4722.1	-1.5938	.68423-02	-.12387-04
9	984.14	4566.9	-.41170	-.16997-02	.35541-05
10	1232.1	4414.5	-.59912	.94378-03	-.98292-06
11	1480.4	4308.8	-.31222	.21143-03	-.19843-06
12	1780.6	4228.8	-.23893	.32769-04	.19977-08
13	4876.0				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R3D-129/156					
1	.00000	.00000	49.203	.00000	.00000
2	12.811	630.32	49.203	.00000	-.68524-02
3	28.506	1376.1	44.139	-.32266	.84789-03
4	88.839	3050.8	14.464	-.16919	.84580-03
5	149.17	3493.3	3.2844	-.16102-01	-.14108-04
6	209.51	3629.8	1.1874	-.18655-01	.45031-04
7	342.36	3563.9	-1.3851	-.70750-03	.52020-05
8	496.65	3352.4	-1.2319	.17003-02	-.94607-06
9	716.37	3153.8	-.62176	.10767-02	-.74269-06
10	1193.7	3021.6	-.10156	.13140-04	.21091-07
11	2519.7	2959.2	.44545-01	.97041-04	-.58817-07
12	3836.3	3051.8	-.57767-02	-.13526-03	.20616-06
13	4873.3				
R5C-097/124					
1	.00000	.00000	38.378	.00000	.00000
2	35.581	1365.5	38.378	.00000	-.14120-01
3	40.121	1538.5	37.505	-.19231	.38058-03
4	151.94	3859.7	8.7718	-.64646-01	.19273-03
5	255.29	4288.6	1.5853	-.48936-02	-.27460-04
6	326.51	4366.7	.47032	-.10761-01	.33056-04
7	393.92	4359.6	-.52989	-.40756-02	.54915-05
8	669.09	4019.7	-1.5254	.45766-03	.21213-05
9	895.86	3722.0	-.99058	.19008-02	-.36814-05
10	1012.5	3626.5	-.69741	.61273-03	-.25802-06
11	2001.6	3286.5	-.24258	-.15288-03	.54689-06
12	2442.3	3196.7	-.58656-01	.57020-03	-.71036-06
13	3675.8				
R5B-121/148					
1	.00000	.00000	106.57	-11.019	3.6075
2	.94207	93.636	95.416	-.82347	.30527-02
3	73.982	3859.3	23.982	-.15455	.37093-03
4	147.02	4930.9	7.3410	-.73276-01	.24497-03
5	220.06	5171.7	.55754	-.19597-01	.22963-04
6	300.52	5101.6	-2.1502	-.14054-01	.72416-04
7	376.22	4889.7	-3.0331	.23901-02	-.53373-06
8	810.76	3979.2	-1.2583	.16943-02	-.10857-05
9	1385.5	3609.6	-.38665	-.17767-03	.14526-05
10	1511.6	3560.9	-.36212	.37213-03	-.15590-06
11	2002.2	3454.4	-.10956	.14267-03	-.39337-07
12	4882.9				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R6A-461/483					
1	.00000	.00000	56.115	.00000	.00000
2	2.0723	116.29	56.115	.00000	-.67922-02
3	18.281	996.90	50.762	-.33027	.86216-03
4	79.321	3060.9	20.080	-.17239	.86302-03
5	115.94	3607.5	10.925	-.77569-01	.19442-03
6	230.71	4133.5	.80291	-.10634-01	.25459-04
7	274.66	4150.5	.15647-01	-.72764-02	.10455-04
8	535.71	3844.7	-1.6459	.91164-03	.81429-08
9	1025.2	3258.4	-.74750	.92360-03	.83572-06
10	1418.0	3056.6	-.40875	-.61145-04	.76279-06
11	1605.2	2983.0	-.35145	.36722-03	-.16098-06
12	2295.3	2862.4	-.74608-01	.33939-04	-.92456-08
13	4651.3				
R8C-165/192					
1	.00000	.00000	71.337	.00000	.00000
2	23.744	1693.8	71.337	.00000	-.53377-01
3	26.823	1911.9	69.818	-.49311	.15226-02
4	111.91	5220.6	18.974	-.10442	.22936-03
5	197.00	6220.4	6.1863	-.45870-01	.11941-03
6	294.14	6497.9	.65501	-.11072-01	-.18366-04
7	395.84	6430.7	-2.1668	-.16675-01	.15076-03
8	434.06	6332.0	-2.7807	.61388-03	.73403-06
9	1002.0	5085.2	-1.3732	.18645-02	-.22675-05
10	1361.9	4726.7	-.91235	-.58401-03	.70951-05
11	1467.6	4632.2	-.79812	.16651-02	-.25766-05
12	1663.0	4520.6	-.44252	.15443-03	-.19652-07
13	4977.0				
R8D-192/219					
1	.00000	.00000	114.24	.00000	.00000
2	5.0929	581.79	114.24	.00000	-.74215-01
3	9.7494	1106.2	109.41	-1.0367	.38967-02
4	79.743	5021.2	21.550	-.21850	.91596-03
5	149.74	5773.2	4.4249	-.26165-01	.10784-04
6	191.73	5913.7	2.2843	-.24806-01	.37111-04
7	374.27	5729.8	-3.0623	-.44833-02	.16832-04
8	561.09	5111.0	-2.9750	.49505-02	-.45018-05
9	869.82	4531.9	-1.2055	.78102-03	.35220-07
10	1532.0	4086.4	-.12484	.85098-03	-.12854-05
11	1879.7	4091.8	.68011-03	-.49004-03	.19887-06
12	3152.7	3708.8	-.28019	.26940-03	-.75344-07
13	4881.0				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R9A-125/152					
1	.00000	.00000	70.902	.00000	.00000
2	2.1816	154.68	70.902	.00000	-.65253-02
3	25.635	1733.4	60.134	-.45912	.11650-02
4	166.88	4350.5	.16701	.34559-01	-.19991-03
5	251.63	4491.2	1.7171	-.16268-01	.57454-04
6	358.98	4559.2	.21075	.22349-02	-.18093-04
7	486.02	4584.9	-.97469-01	-.46610-02	.13513-04
8	617.69	4522.1	-.62208	.67666-03	-.31516-06
9	915.57	4388.5	-.30284	.39504-03	-.28322-0
10	1213.5	4325.9	-.14288	.14196-03	-.13858-07
11	1990.1	4294.0	.52534-01	.10967-03	-.12732-06
12	2422.2	4326.9	.75993-01	-.55384-04	.25390-07
13	4882.7				
R9B-043/070					
1	.00000	.00000	121.42	-3.5765	.80941-01
2	12.062	1086.3	70.471	-.64744	.20131-02
3	138.73	3716.0	3.3487	.11753	-.13314-02
4	184.33	3986.8	5.7615	-.64614-01	.29038-03
5	253.74	4172.5	.98872	-.41469-02	.57982-05
6	365.28	4239.3	.28003	-.22067-02	.16372-05
7	859.55	4036.3	-.70143	.22104-03	.28498-05
8	973.26	3963.6	-.54063	.11932-02	-.27828-05
9	1066.4	3921.3	-.39081	.41584-03	-.13675-06
10	2471.9	3813.8	-.32298-01	-.16077-03	.19879-06
11	3026.5	3780.4	-.27188-01	.16998-03	-.90209-07
12	4885.4				
R10A-195/222					
1	.00000	.00000	50.252	.00000	.00000
2	.99259	49.879	50.252	.00000	-.47315-02
3	20.878	1011.9	44.639	-.28226	.74575-03
4	113.63	3319.1	11.525	-.74747-01	.16641-03
5	206.38	3877.8	1.9542	-.28441-01	.13874-03
6	262.04	3922.4	.77630-01	-.52777-02	.18730-05
7	353.04	3887.2	-.83641	-.47664-02	.18844-04
8	449.48	3779.1	-1.2300	.68549-03	-.11861-06
9	1238.8	3177.0	-.36949	.40462-03	-.48576-06
10	1600.5	3073.3	-.26743	-.12248-03	.28961-06
11	2003.4	2964.6	-.22512	.22752-03	-.16281-06
12	2509.0	2887.9	-.11990	-.19456-04	.12792-07
13	4969.7				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R10D-157/184					
1	.00000	.00000	61.981	-8.4960	6.2220
2	.43843	26.066	58.120	-.31227	.64479-03
3	144.05	3842.1	8.3235	-.34483-01	.56109-04
4	308.33	4527.7	1.5366	-.68277-02	.17111-04
5	339.35	4569.3	1.1624	-.52343-02	.42932-05
6	584.47	4602.9	-.62976	-.20772-02	.56634-05
7	769.29	4451.3	-.81720	.10630-02	-.21819-05
8	954.12	4322.8	-.64786	-.14678-03	.44560-06
9	1465.5	4012.7	-.44839	.53683-03	-.15104-05
10	1585.7	3964.0	-.38481	-.77993-05	.19964-06
11	1875.1	3856.8	-.33916	.16552-03	-.35825-07
12	4600.3				
R1C-210/236					
1	.00000	.00000	51.234	.00000	.00000
2	.36721	18.814	51.234	.00000	-.26916-02
3	25.741	1274.8	46.036	-.20489	.31784-03
4	96.101	3610.3	21.924	-.13780	.31777-03
5	166.46	4581.4	7.2530	-.70722-01	.23560-03
6	236.82	4823.7	.80003	-.20991-01	.41228-04
7	324.28	4760.7	-1.9256	-.10174-01	.35323-04
8	432.96	4476.6	-2.8855	.13425-02	.10389-05
9	726.96	3770.7	-1.8267	.22588-02	-.16363-05
10	1076.3	3338.4	-.84755	.54376-03	.18820-07
11	1425.7	3109.5	-.46071	.56349-03	-.43136-06
12	1849.0	2982.7	-.21554	.15732-04	.58651-08
13	4844.1				
R1C-240/266					
1	.00000	.00000	290.49	-31.192	2.0411
2	4.8999	914.59	131.83	-1.1882	.33709-02
3	74.877	5476.0	15.050	-.48057	.33740-02
4	144.85	5332.0	-2.6441	.22772	-.17933-02
5	214.83	5647.6	2.8828	-.14874	.14021-02
6	229.83	5662.1	-.63299	-.85647-01	.12365-02
7	253.00	5616.8	-2.6104	.30051-03	.11987-05
8	649.49	4703.8	-1.8068	.17263-02	-.10600-05
9	922.01	4318.2	-1.1020	.85967-03	-.33441-06
10	1661.1	3838.3	-.37932	.11824-03	-.20706-07
11	2447.0	3603.1	-.23182	.69418-04	-.15197-07
12	4894.7				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
-----	------	------	------	------	------
R1D-209/236					
1	.00000	.00000	79.553	.00000	.00000
2	12.701	1010.4	79.553	.00000	-.89328-01
3	14.145	1125.0	78.994	-.38680	.67470-03
4	76.145	4696.5	38.811	-.26131	.67558-03
5	138.14	6259.4	14.199	-.13565	.34632-03
6	259.77	6602.8	-3.4290	-.92842-02	-.77795-04
7	322.82	6330.2	-5.5271	-.23997-01	.15425-03
8	400.76	5826.7	-6.4566	.12073-01	-.10641-04
9	721.95	4645.7	-1.9949	.18189-02	-.75291-06
10	1370.1	3911.8	-.58600	.35482-03	-.16827-06
11	2426.9	3490.2	-.39982	-.17864-03	.23967-06
12	3170.9	3192.5	-.26760	.35634-03	-.20484-06
13	4781.3				
R1D-315/342					
1	.00000	.00000	65.410	-1.7213	.49123-01
2	9.5631	511.06	45.966	-.31200	.71749-03
3	84.316	2503.4	11.348	-.15110	.71681-03
4	159.07	2806.7	.77445	.96565-02	-.99734-04
5	233.82	2876.9	.54620	-.12711-01	.29197-04
6	248.82	2882.4	.18457	-.11399-01	.29677-04
7	374.91	2783.9	-1.2745	-.17305-03	.11237-05
8	725.15	2364.6	-.98215	.10077-02	-.63083-06
9	1075.4	2117.1	-.50846	.34483-03	-.15114-06
10	1425.6	1974.8	-.32253	.18602-03	-.42619-07
11	3182.3	1751.3	-.63533-01	-.38587-04	.17327-07
12	4955.8				
R3C-329/359					
1	.00000	.00000	59.199	.00000	.00000
2	29.853	1767.3	59.199	.00000	-.28178
3	30.329	1795.4	59.008	-.40204	.10469-02
4	121.95	4632.1	11.702	-.11427	.44920-03
5	213.58	5090.5	2.0749	.91993-02	-.16686-03
6	246.56	5163.0	2.1371	-.73124-02	.63891-05
7	423.14	5347.5	.15233	-.39279-02	.33317-05
8	651.02	5217.7	-1.1188	-.16502-02	.40377-05
9	840.83	4973.5	-1.3089	.64890-03	-.23274-06
10	1560.8	4280.7	-.73645	.14620-03	.30342-05
11	1664.4	4209.3	-.60838	.10896-02	-.26567-05
12	1775.8	4151.4	-.46452	.20145-03	-.35050-07
13	4192.2				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R3C-411/438					
1	.00000	.00000	30.254	.00000	.00000
2	12.832	388.21	30.254	.00000	-.37525-02
3	31.772	935.73	26.216	-.21322	.60787-03
4	91.013	1866.8	7.3525	-.10519	.60696-03
5	150.25	2059.4	1.2799	.26816-02	-.10692-03
6	209.50	2122.4	.47183	-.16321-01	.14071-03
7	244.83	2125.0	-.15454	-.14051-02	.17561-05
8	617.05	1963.3	-.47061	.55594-03	-.87781-06
9	781.34	1897.1	-.35901	.12331-03	-.33579-07
10	1627.3	1661.3	-.22248	.38085-04	.33488-06
11	1947.3	1605.0	-.95226-01	.35957-03	-.36107-06
12	2486.3	1601.6	-.22306-01	-.22429-03	.11181-06
13	4194.3				
R3D-250/277					
1	.00000	.00000	47.880	.00000	.00000
2	32.435	1553.0	47.880	.00000	-.16757-01
3	36.879	1764.3	46.887	-.22342	.39993-03
4	177.57	5052.3	7.7688	-.54618-01	.20346-03
5	234.41	5354.7	3.5319	-.19926-01	.20841-04
6	324.89	5526.6	.43783	-.14269-01	.77635-04
7	365.67	5526.0	-.33855	-.47719-02	.61838-05
8	671.37	5153.2	-1.5224	.89945-03	-.11504-06
9	1078.3	4674.9	-.84744	.75900-03	-.36373-06
10	1868.7	4299.6	-.32931	-.10345-03	.17272-05
11	2052.2	4246.4	-.19290	.84705-03	-.43422-05
12	2118.2	4236.1	-.13783	-.13819-04	.97287-08
13	4871.8				
R3D-318/345					
1	.00000	.00000	55.585	.00000	.00000
2	20.612	1145.7	55.585	.00000	-.13473-01
3	27.748	1537.5	53.527	-.28844	.56816-03
4	187.14	5041.9	4.8800	-.16769-01	.29464-04
5	363.29	5542.2	1.7150	-.11987-02	-.21639-04
6	476.70	5689.7	.60803	-.85612-02	.26293-04
7	559.67	5696.3	-.26960	-.20168-02	.18541-05
8	1071.3	5278.8	-.87732	.82885-03	-.18884-05
9	1306.7	5093.5	-.80106	-.50489-03	.29482-05
10	1490.0	4947.8	-.68889	.11167-02	-.15930-05
11	1724.8	4827.0	-.42797	-.52243-05	.93475-07
12	2335.8	4584.9	-.32965	.16612-03	-.47142-07
13	4875.6				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R5C-250/277					
1	.00000	.00000	52.874	.00000	.00000
2	16.649	880.32	52.874	.00000	-.99325-02
3	26.344	1383.9	50.074	-.28889	.10480-02
4	70.777	3130.4	30.609	-.14919	.33412-03
5	185.93	5187.0	9.5407	-.33762-01	.11907-03
6	203.15	5341.8	8.4842	-.27611-01	.19822-04
7	633.50	5459.3	-4.2671	-.20190-02	.39457-04
8	711.45	5133.1	-3.8626	.72078-02	-.11068-04
9	868.98	4660.2	-2.4157	.19773-02	.20933-05
10	1130.7	4200.9	-.95059	.36207-02	-.48846-04
11	1206.0	4129.1	-1.2358	-.74094-02	.33558-04
12	1321.6	3939.0	-1.6035	.42283-02	-.48544-05
13	1802.7				
R5C-328/355					
1	.00000	.00000	347.81	-76.262	7.3018
2	3.4471	591.81	82.328	-.75277	.26049-02
3	104.63	3913.6	9.9997	.37972-01	-.57154-03
4	165.35	4532.8	8.2905	-.66125-01	.18909-03
5	266.53	4890.5	.71660	-.87259-02	-.15800-04
6	367.72	4857.3	-1.5347	-.13522-01	.69017-04
7	413.79	4764.7	-2.3412	-.39837-02	.88662-05
8	721.26	3925.9	-2.2763	.41946-02	-.81609-05
9	840.37	3700.5	-1.6244	.12785-02	-.50009-06
10	1467.6	3061.2	-.61084	.33748-03	-.81215-07
11	2797.4	2654.7	-.14415	.13478-04	-.12731-08
12	4888.3				
R5D-255/282					
1	.00000	.00000	49.826	-.29187-01	-.22374-02
2	30.187	1415.9	41.948	-.23181	.51485-03
3	159.13	4074.5	7.8488	-.32652-01	.68242-04
4	236.49	4517.9	4.0219	-.16814-01	.32497-04
5	373.54	4836.9	1.2444	-.34532-02	-.25208-04
6	435.01	4894.5	.53411	-.81018-02	.10737-04
7	759.44	4581.7	-1.3324	.23486-02	-.28048-05
8	1116.9	4277.4	-.72850	-.65896-03	.31090-05
9	1184.4	4226.2	-.77497	-.29541-04	.52204-06
10	1776.6	3865.3	-.26068	.89795-03	-.23211-05
11	1896.3	3843.0	-.14548	.64157-04	-.20664-07
12	4889.8				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R5D-325/352					
1	.00000	.00000	54.778	.00000	.00000
2	19.749	1081.8	54.778	.00000	-.13886-01
3	26.769	1461.6	52.725	-.29243	.65575-03
4	157.63	4822.9	9.8771	-.35000-01	.47367-04
5	311.41	5686.3	2.4731	-.13148-01	.43907-05
6	431.21	5801.5	-.48815	-.11570-01	.14775-03
7	449.00	5790.0	-.75951	-.36847-02	.39028-05
8	757.65	5319.3	-1.9187	-.70903-04	.14043-05
9	1115.6	4687.8	-1.4297	.14369-02	-.44747-05
10	1182.7	4597.0	-1.2973	.53590-03	.57592-07
11	1692.3	4082.7	-.70626	.62394-03	-.70802-06
12	1878.7	3968.1	-.54743	.22791-03	-.33522-07
13	4883.7				
R6A-661/688					
1	.00000	.00000	53.461	-.24152	-.73667-02
2	1.5832	84.007	52.641	-.27651	.35276-03
3	44.851	1872.6	30.694	-.23072	.63361-03
4	145.81	3271.7	3.4814	-.38817-01	.18996-03
5	196.92	3373.6	1.0022	-.96914-02	.71205-05
6	229.88	3396.4	.38663	-.89873-02	.16725-04
7	409.15	3273.2	-1.2232	.79697-05	-.82269-05
8	452.88	3219.1	-1.2697	-.10711-02	.47898-05
9	738.10	2880.9	-.71165	.30274-02	-.12962-04
10	893.03	2795.1	-.70696	-.29972-02	.26099-04
11	956.49	2744.9	-.77204	.19716-02	-.21835-05
12	1447.9				
R6C-589/616					
1	.00000	.00000	102.60	-4.9382	.62201
2	2.2418	212.21	89.841	-.75487	.26307-02
3	79.225	3855.0	20.388	-.14731	.40816-03
4	195.62	4876.0	2.6844	-.47955-02	-.11296-03
5	253.63	4993.5	.98759	-.24454-01	.85112-04
6	328.92	4965.6	-1.2474	-.52284-02	.12419-04
7	458.26	4743.6	-1.9766	-.40966-03	-.46023-05
8	613.79	4409.0	-2.4380	-.25568-02	.81091-04
9	643.16	4337.2	-2.3784	.45875-02	-.65594-05
10	980.06	3805.8	-1.5209	-.20422-02	.11055-04
11	1151.0	3541.4	-1.2502	.36260-02	-.28840-05
12	2286.6				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
RBC-444/471					
1	.00000	.00000	68.558	.00000	.00000
2	20.252	1388.4	68.558	.00000	-.12283
3	22.367	1532.3	66.909	-.77957	.44149-02
4	71.724	3466.4	22.220	-.12585	.21872-03
5	129.74	4374.7	9.8262	-.87785-01	.51230-03
6	166.08	4640.4	5.4754	-.31930-01	.42948-04
7	363.60	4807.1	-2.1116	-.64806-02	.15226-04
8	553.34	4277.2	-2.9265	.21862-02	.31445-05
9	637.52	4048.2	-2.4916	.29804-02	-.22394-05
10	1066.3	3351.3	-1.1709	.99989-04	.19242-05
11	1433.6	3030.1	-.31860	.22203-02	-.33060-04
12	1474.4	3018.5	-.30265	-.18299-02	.18455-05
13	2485.3				
RBC-508/535					
1	.00000	.00000	43.600	.00000	.00000
2	10.290	448.63	43.600	.00000	-.17230-01
3	15.375	668.08	42.263	-.26285	.57132-03
4	76.202	2394.9	16.628	-.15860	.56876-03
5	137.03	2947.5	3.6467	-.54812-01	.25096-03
6	197.85	3023.0	-.23585	-.90173-02	-.28597-04
7	275.47	2937.0	-2.1523	-.15676-01	.10608-03
8	348.91	2736.4	-2.7383	.76967-02	-.66115-04
9	376.19	2666.1	-2.4660	.22853-02	-.87952-06
10	1097.9	1746.0	-.54166	.38102-03	-.18897-06
11	2028.8	1419.6	-.32354	-.14670-03	.32842-06
12	2499.1	1269.1	-.24359	.31669-03	-.10882-06
13	4979.3				
RBD-477/504					
1	.00000	.00000	41.566	-.70015-01	-.37805-02
2	23.171	878.51	32.232	-.33282	.11925-02
3	122.91	1965.6	1.4302	.23998-01	-.21995-03
4	182.76	2090.0	1.9394	-.15489-01	.45827-04
5	271.13	2172.1	.27539	-.33397-02	.63545-05
6	503.60	2135.4	-.24715	.10920-02	-.35002-05
7	730.41	2094.7	-.29200	-.12897-02	.84642-05
8	801.78	2070.4	-.34674	.52271-03	-.46523-06
9	1132.2	1996.1	-.15369	.61529-04	-.95690-07
10	1754.4	1901.2	-.18825	-.11709-03	.58305-06
11	1874.8	1877.9	-.19109	.93521-04	-.29293-07
12	4885.2				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R8D-565/592					
1	.00000	.00000	76.666	-3.1742	.33373
2	2.7895	196.41	66.748	-.38139	.88887-03
3	70.176	3234.4	27.456	-.20170	.88489-03
4	110.61	4073.3	15.485	-.94365-01	.17913-03
5	258.18	4879.1	-.66347	-.15062-01	.15353-04
6	338.03	4737.9	-2.7752	-.11384-01	.37480-04
7	492.66	4175.2	-3.6075	.60019-02	-.67505-05
8	716.17	3593.3	-1.9362	.14755-02	-.23893-06
9	1070.0	3082.4	-.98172	.12219-02	-.81435-06
10	1423.8	2851.9	-.42288	.35748-03	-.14759-06
11	2401.4	2642.3	-.14709	-.75347-04	.43331-07
12	4884.8				
R9A-523/550					
1	.00000	.00000	63.900	-.49594	.55747-02
2	39.535	2095.6	50.826	.16524	-.42497-02
3	71.141	3732.9	48.535	-.23771	-.42703-02
4	102.75	4894.6	20.711	-.64262	.68019-02
5	134.35	5122.1	.47407	.23378-02	-.80899-05
6	152.35	5131.3	.55036	.19006-02	-.80179-05
7	444.41	5254.4	-.39119	-.51245-02	.75541-05
8	665.02	4999.8	-1.5493	-.12511-03	.76831-06
9	1033.2	4450.9	-1.3290	.72343-03	-.18875-06
10	2085.1	3633.7	-.43361	.12779-03	.77335-07
11	2757.3	3423.4	-.15696	.28375-03	-.62229-06
12	3885.7				
R9B-449/476					
1	.00000	.00000	55.239	.00000	.00000
2	6.7075	370.52	55.239	.00000	-.51290-02
3	31.169	1646.7	46.032	-.37639	.10370-02
4	97.612	3347.7	9.7497	-.16968	.10363-02
5	164.05	3550.4	.92614	.36885-01	-.31381-03
6	230.50	3682.7	1.6715	-.25667-01	.16726-03
7	268.96	3718.6	.43938	-.63649-02	.76362-05
8	557.87	3498.4	-1.3262	.25359-03	.74350-06
9	954.49	3058.7	-.77419	.11381-02	-.79851-05
10	980.93	3038.9	-.73076	.50447-03	-.12422-06
11	2828.8	2627.3	-.13887	-.18424-03	.32258-05
12	2884.8	2619.5	-.12911	.35823-03	-.16901-06
13	4884.4				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R9C-395/422					
1	.00000	.00000	92.351	.00000	.00000
2	15.131	1397.3	92.351	.00000	-.46974
3	15.691	1449.0	91.909	-.78932	.23151-02
4	122.08	5080.9	2.5705	-.50382-01	.36941-03
5	185.92	5135.8	.65428	.20363-01	-.14681-03
6	252.18	5225.8	1.4191	-.88201-02	.84107-05
7	330.03	5286.8	.19881	-.68559-02	.78471-05
8	674.33	4862.8	-1.7315	.12494-02	-.47285-06
9	1424.7	4067.3	-.65514	.18500-03	.32862-06
10	1874.2	3840.0	-.28970	.62809-03	-.85231-06
11	2399.6	3737.6	-.33554	-.71533-03	.14170-05
12	2710.8	3606.6	-.36899	.60789-03	-.25799-06
13	4879.7				
R9D-317/344					
1	.00000	.00000	63.391	.00000	.00000
2	31.379	1989.1	63.391	.00000	-.12136
3	33.031	2093.3	62.397	-.60145	.20696-02
4	117.19	4318.3	5.1374	-.78934-01	.41020-03
5	191.58	4432.5	.20371	.12616-01	-.63414-04
6	285.50	4510.4	.89537	-.52518-02	.43443-05
7	819.22	4152.8	-.99810	.17041-02	-.90586-04
8	866.81	4099.4	-1.4515	-.11230-01	.11722-03
9	934.38	3986.2	-1.3634	.12533-01	-.12943-03
10	966.09	3951.4	-.95898	.22078-03	.47523-07
11	1921.2	3278.3	-.40717	.35695-03	-.13418-05
12	1983.5	3254.0	-.37832	.10631-03	-.28658-09
13	4882.9				
R10A-320/347					
1	.00000	.00000	66.934	-.11046	-.22871-02
2	25.188	1579.3	57.017	-.28328	.52062-03
3	85.114	4090.9	28.674	-.18968	.52068-03
4	145.04	5240.1	11.550	-.96072-01	.31549-03
5	204.97	5655.2	3.4348	-.39353-01	.62585-04
6	348.71	5521.7	-3.9990	-.12365-01	.37937-04
7	519.32	4667.9	-4.9054	.70522-02	-.54991-05
8	713.52	3941.0	-2.7884	.38484-02	-.23373-05
9	1065.4	3334.5	-.94828	.13811-02	-.87246-06
10	1783.2	3042.7	-.31419	-.49774-03	.12150-05
11	1994.3	2965.6	-.36189	.27180-03	-.63706-07
12	4872.8				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R10B-418/445					
1	.00000	.00000	53.178	.00000	.00000
2	59.547	3166.6	53.178	.00000	-.13526-01
3	69.012	3658.5	49.543	-.38409	.11242-02
4	173.28	5922.8	6.1115	-.32429-01	.10908-03
5	249.30	6247.9	3.0721	-.75543-02	.88269-05
6	509.54	6691.3	.93367	-.66311-03	-.68645-04
7	573.78	6730.4	-.15556-02	-.13894-01	.23572-03
8	592.84	6726.9	-.27430	-.41900-03	-.21272-07
9	1182.9	6414.9	-.79094	-.45647-03	.60737-05
10	1221.6	6383.9	-.79897	.24901-03	-.25790-07
11	3122.2	5587.8	-.13190	.10196-03	-.19468-06
12	3597.4	5527.3	-.16687	-.17556-03	.18195-06
13	4859.8				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R1A-175/201					
1	.00000	.00000	18940.	.00000	.00000
2	.46971	8896.1	18940.	.00000	-.13790+06
3	.51184	9683.7	18205.	-17429.	4420.4
4	.79184	13512.	9484.7	-13716.	4405.5
5	1.0718	15189.	2839.7	-10016.	1983.9
6	1.3218	15304.	-1796.1	-8527.7	1195.3
7	1.5718	14341.	-5835.8	-7631.2	8322.7
8	2.0742	10538.	-7202.0	4911.6	-1293.6
9	3.2664	6741.0	-1006.8	284.75	48.284
10	4.8006	5692.3	-474.00	62.523	-4.9113
11	8.2367	4602.6	-218.29	11.896	-.42486
12	17.707				
R1B-131/157					
1	.00000	.00000	11093.	.00000	.00000
2	.30321	3363.5	11093.	.00000	-3179.7
3	.49047	5419.9	10758.	-1786.3	-662.19
4	1.2355	12170.	6994.2	-3266.3	-656.87
5	1.9805	15296.	1033.7	-4734.4	2131.3
6	2.2305	15292.	-933.91	-3136.0	2177.9
7	2.4805	14896.	-2093.6	-1502.6	628.30
8	4.0888	10256.	-2051.1	1529.0	-893.55
9	4.5791	9512.8	-1196.2	214.65	-23.126
10	7.0482	7519.7	-559.21	43.356	-1.6057
11	15.155	4980.1	-172.84	4.3024	-.55957-01
12	49.075				
R2A-110/135					
1	.00000	.00000	14287.	.00000	.00000
2	.25472	3639.1	14287.	.00000	30059.
3	.26855	3837.9	14472.	7317.7	-.52196+06
4	.30255	4318.0	13159.	-45927.	.85091+06
5	.35888				

STRAIN RATE = (10E-3)/SEC
TEMPERATURE = -5°C

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R1A-175/201					
1	.00000	.00000	18940.	.00000	.00000
2	.46971	8896.1	18940.	.00000	-.13790+06
3	.51184	9683.7	18205.	-17429.	4420.4
4	.79184	13512.	9484.7	-13716.	4405.5
5	1.0718	15189.	2839.7	-10016.	1983.9
6	1.3218	15304.	-1796.1	-8527.7	1195.3
7	1.5718	14341.	-5835.8	-7631.2	8322.7
8	2.0742	10538.	-7202.0	4911.6	-1293.6
9	3.2664	6741.0	-1006.8	284.75	48.284
10	4.8006	5692.3	-474.00	62.523	-4.9113
11	8.2367	4602.6	-218.29	11.896	-.42486
12	17.707				
R1B-131/157					
1	.00000	.00000	11093.	.00000	.00000
2	.30321	3363.5	11093.	.00000	-3179.7
3	.49047	5419.9	10758.	-1786.3	-662.19
4	1.2355	12170.	6994.2	-3266.3	-656.87
5	1.9805	15296.	1033.7	-4734.4	2131.3
6	2.2305	15292.	-933.91	-3136.0	2177.9
7	2.4805	14896.	-2093.6	-1502.6	628.30
8	4.0888	10256.	-2051.1	1529.0	-893.55
9	4.5791	9512.8	-1196.2	214.65	-23.126
10	7.0482	7519.7	-559.21	43.356	-1.6057
11	15.155	4980.1	-172.84	4.3024	-.55957-01
12	49.075				
R2A-110/135					
1	.00000	.00000	14287.	.00000	.00000
2	.25472	3639.1	14287.	.00000	30059.
3	.26855	3837.9	14472.	7317.7	-.52196+06
4	.30255	4318.0	13159.	-45927.	.85091+06
5	.35888				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R2B-135/161					
1	.00000	.00000	15358.	.00000	.00000
2	.16923	2599.0	15358.	.00000	-20166.
3	.36539	5459.5	13031.	-11864.	-57258.
4	.41417	6060.2	11465.	-20243.	.10702+06
5	.49471	6908.3	10287.	5619.3	-35873.
6	.71668	9076.3	7479.4	-18268.	.26035+06
7	.75690	9364.4	7273.3	13142.	-81963.
8	.92787				
R3A-188/213					
1	.00000	.00000	13686.	.00000	.00000
2	.42068	5757.3	13686.	.00000	-43496.
3	.50160	6841.7	12831.	-10560.	2503.3
4	.88160	10330.	5890.4	-7705.9	2412.5
5	1.2616	11588.	1079.1	-4955.6	2551.8
6	1.5116	11588.	-920.27	-3041.7	2427.1
7	1.7616	11206.	-1986.1	-1221.4	983.02
8	2.1224	10376.	-2483.5	-157.27	974.83
9	2.3865	9727.6	-2362.7	614.86	-63.277
10	5.5172	6415.4	-373.45	20.544	-.49264
11	18.116	3986.2	-90.372	1.9247	-.20276-01
12	49.887				
R3B-130/155					
1	.00000	.00000	14320.	.00000	.00000
2	.32102	4596.8	14320.	.00000	-17695.
3	.55397	7708.9	11439.	-12366.	3717.3
4	.80647	9868.6	5904.9	-9550.3	3573.0
5	1.0590	10808.	1765.3	-6843.8	3793.5
6	1.3090	10881.	-945.27	-3998.6	3557.7
7	1.5590	10450.	-2277.5	-1330.3	1150.6
8	1.9675	9376.5	-2788.4	79.696	1107.8
9	2.1907	8770.4	-2587.2	821.63	-102.76
10	4.7252	5818.1	-402.60	40.322	-1.6934
11	12.219	4352.8	-83.563	2.2491	-.27078-01
12	49.059				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R4A-283/309					
1	.00000	.00000	14819.	.00000	.00000
2	.31931	4732.0	14819.	.00000	-15812.
3	.52702	7670.1	12791.	-9809.5	5787.0
4	.66733	9287.7	10380.	-7373.6	-41323.
5	.80211	10452.	6139.8	-24083.	.10125+06
6	.92307	11021.	4758.3	12661.	-.63637+06
7	1.0095				
R4B-299/325					
1	.00000	.00000	12769.	.00000	.00000
2	.54611	6973.2	12769.	.00000	-.33446+06
3	.55794	7123.8	12628.	-11878.	2825.1
4	.82794	9723.2	6832.2	-9589.6	2906.2
5	1.0979	10926.	2289.4	-7235.6	2671.8
6	1.3479	11088.	-827.47	-5231.7	2937.4
7	1.5979	10600.	-2892.6	-3028.7	2816.6
8	2.2723	8135.6	-3134.6	2669.9	-1241.2
9	2.9309	6874.7	-1232.9	217.53	-16.225
10	7.1064	4338.0	-264.98	14.290	-.37480
11	18.190	2646.3	-86.343	1.8275	-.18087-01
12	48.628				
R5A-135/161					
1	.00000	.00000	23586.	.00000	.00000
2	.19089	4502.4	23586.	.00000	-.13406+06
3	.19940	4703.1	23564.	-3003.1	2864.1
4	.30268	7107.8	23036.	-2116.0	-.20458+06
5	.39924	9128.4	16904.	-61380.	.46384+06
6	.47903	10322.	15968.	49647.	-.89517+06
7	.51687	10949.	15880.	-51988.	.29420+06
8	.60034	12083.	13350.	21676.	-.18256+06
9	.77705				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R5B-141/167					
1	.00000	.00000	15136.	.00000	.00000
2	.27121	4105.0	15136.	.00000	-30588.
3	.27169	4112.3	15136.	-38.715	-5984.4
4	.50352	7544.8	14153.	-4201.0	27169.
5	.61266	9074.7	14207.	4693.5	-.18359+06
6	.64701	9560.8	13880.	-14223.	40741.
7	.80601	11572.	12447.	5210.5	-33290.
8	.96501	13549.	11579.	-10669.	20051.
9	1.2258				
R7A-005/031					
1	.00000	.00000	10634.	.00000	.00000
2	.16402	1744.1	10634.	.00000	-.29571+06
3	.17024	1810.2	10600.	-5471.8	12738.
4	.39615	4072.4	10078.	3160.9	-53758.
5	.44574	4573.4	9994.8	-4836.8	7734.5
6	.70207	6947.9	9039.7	1111.0	-26801.
7	.88654	8485.0	6713.7	-13720.	70765.
8	1.0022	9187.7	6381.0	10845.	-.50822+06
9	1.0849				
R7B-072/098					
1	.00000	.00000	22913.	.00000	.00000
2	.11785	2700.2	22913.	.00000	-.73530+06
3	.16691	3737.8	17616.	-.10810+06	.33806+06
4	.26659	4754.5	6141.8	-7001.3	-6395.6
5	.41485	5490.3	3644.0	-9845.9	24262.
6	.60164	5985.6	2505.2	3749.2	-39364.
7	.75279	6313.9	940.43	-14101.	39090.
8	1.0627				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R8A-033/059					
1	.00000	.00000	5952.4	.00000	.00000
2	.75479	4492.8	5952.4	.00000	64288.
3	.75495				
R8B-011/037					
1	.00000	.00000	15116.	.00000	.00000
2	.23845	3604.4	15116.	.00000	-.29782+06
3	.25168	3803.7	14961.	-11757.	34288.
4	.45797	6690.7	14488.	9462.9	-.11308+06
5	.54993	8015.2	13360.	-21733.	.13019+06
6	.63246	9042.9	12432.	10500.	-.11874+07
7	.69141				
R2C-049/076					
1	.00000	.00000	8084.5	.00000	.00000
2	.48159	3893.4	8084.5	.00000	-5440.0
3	.86330	6676.8	5706.6	-6229.5	1696.1
4	1.0608	7574.0	3444.4	-5224.6	1551.1
5	1.2583	8062.4	1562.2	-4305.6	1727.6
6	1.5083	8210.9	-266.64	-3009.9	1448.6
7	1.7583	7978.7	-1500.0	-1923.4	2016.6
8	1.8808	7769.8	-1880.4	-1182.5	1580.5
9	2.2338	7028.1	-2124.3	491.52	-41.631
10	6.0902	3758.1	-190.73	9.8787	-.19090
11	23.983	2414.5	-20.569	-.36844	.18786-01
12	49.898				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R2D-134/161					
1	.00000	.00000	8892.0	.00000	.00000
2	.66843	5943.6	8892.0	.00000	-.16594+06
3	.68360	6078.0	8777.4	-7551.9	1827.4
4	1.0711	8451.6	3747.9	-5427.6	1839.0
5	1.4586	9195.9	369.90	-3289.7	1834.7
6	1.7086	9111.4	-930.96	-1913.7	1834.2
7	1.9586	8787.7	-1543.9	-538.06	325.04
8	3.0336	6910.0	-1573.8	510.21	-111.81
9	3.9657	5795.8	-914.12	197.56	-19.449
10	6.9882	4300.7	-252.88	21.208	-.88880
11	14.044	3260.0	-86.350	2.3941	-.31429-01
12	49.824				
R4C-244/271					
1	.00000	.00000	10936.	.00000	.00000
2	.84974	9292.9	10936.	.00000	-.44946+06
3	.92014				
R4C-309/336					
1	.00000	.00000	8423.4	.00000	.00000
2	.55312	4659.1	8423.4	.00000	-18190.
3	.61842	5204.2	8190.7	-3563.8	348.41
4	1.3509	9428.6	3530.5	-2798.2	343.74
5	2.0834	10648.	-15.512	-2042.8	944.26
6	2.3334	10532.	-859.87	-1334.6	933.94
7	2.5834	10248.	-1352.1	-634.18	294.94
8	3.7225	8320.9	-1648.8	373.67	-40.336
9	5.9036	6083.7	-594.42	109.74	-10.724
10	8.7967	5022.8	-228.74	16.661	-.61673
11	16.739	3948.1	-80.797	1.9665	-.27602-01
12	49.868				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R4D-228/255					
1	.00000	.00000	12653.	.00000	.00000
2	.39871	5045.0	12653.	.00000	-.25517+06
3	.45915	5753.9	9873.6	-46128.	.92024+06
4	.48359	5981.1	9267.7	21332.	-93024.
5	.66911				
R7C-007/034					
1	.00000	.00000	18421.	.00000	.00000
2	.29773	5484.5	18421.	.00000	-.84240+06
3	.32238	5926.3	16919.	-61613.	.20356+06
4	.42735	7259.0	10713.	2494.2	-21567.
5	.56548	8729.5	10168.	-6442.5	-3324.0
6	.70360	10002.	8197.9	-7820.0	-1207.5
7	.93013				
R6A-398/425					
1	.00000	.00000	11671.	.00000	.00000
2	.21456	2504.1	11671.	.00000	-47579.
3	.24054	2806.4	11574.	-3708.3	-848.04
4	.79054	7909.4	6725.6	-5107.6	-894.95
5	1.3405	9914.6	295.08	-6584.2	4601.6
6	1.5905	9648.7	-2134.2	-3133.0	4489.2
7	1.8405	8989.5	-2859.0	233.88	155.73
8	2.9735	6276.9	-1729.3	763.20	-157.16
9	4.4087	4902.5	-509.83	86.547	-10.732
10	6.2970	4176.1	-297.78	25.749	-1.2786
11	12.006	3077.4	-128.80	3.8516	-.46789-01
12	49.996				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R6A-504/531					
1	.00000	.00000	9014.1	-1574.8	796.35
2	.41953	3563.3	8113.3	-572.54	-1241.2
3	1.0445	8107.4	5943.0	-2899.8	-1248.6
4	1.6695	10384.	855.07	-5240.9	3523.8
5	1.9195	10326.	-1104.7	-2598.1	3617.6
6	2.1695	9943.5	-1725.5	115.08	14.000
7	2.6394	9159.7	-1608.1	134.81	14.054
8	4.7289	6516.4	-860.63	222.90	-26.456
9	7.3888	5306.4	-236.36	11.783	-.26568
10	19.959	3669.4	-66.074	1.7640	-.25121-01
11	49.975				
R7D-088/114					
1	.00000	.00000	22267.	-21213.	19644.
2	.20110	3779.7	16118.	-9361.5	1727.4
3	.78360	10334.	6970.5	-6342.8	1728.6
4	1.3661	12583.	1340.6	-3322.2	1712.9
5	1.6161	12738.	.68349	-2037.5	536.50
6	1.8661	12619.	-917.46	-1635.1	521.43
7	3.7544	8567.0	-1514.8	1318.8	-700.84
8	4.3622	7976.1	-688.40	40.997	2.4792
9	5.9434	6999.9	-540.15	52.757	-2.3417
10	12.891	5008.4	-146.18	3.9515	-.48775-01
11	50.021				
R9C-080/107					
1	.00000	.00000	10462.	.00000	.00000
2	.21541	2253.6	10462.	.00000	-87440.
3	.22487	2352.5	10438.	-2481.2	-333.67
4	.96737	8598.4	6201.8	-3224.5	-331.66
5	1.7099	11290.	864.90	-3963.3	2089.7
6	1.9599	11291.	-724.92	-2396.0	2136.3
7	2.2099	10993.	-1522.4	-793.80	349.39
8	3.5420	8382.6	-1777.2	602.50	-99.025
9	5.3284	6566.0	-572.64	71.801	-3.8739
10	10.500	4989.1	-140.82	11.700	-.73017
11	15.000	4525.8	-79.874	1.8426	-.21283-01
12	49.990				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R9D-082/109					
1	.00000	.00000	9935.1	.00000	.00000
2	.11763	1168.6	9935.1	.00000	-2130.7
3	.34445	3397.2	9606.3	-1449.9	-1280.3
4	.93195	8280.9	6576.9	-3706.4	-1292.0
5	1.5194	10604.	884.02	-5983.6	3334.8
6	1.7694	10503.	-1482.5	-3482.5	3345.7
7	2.0194	9966.6	-2596.4	-973.20	666.52
8	3.1214	6815.5	-2313.1	1230.3	-282.61
9	4.5173	5215.3	-530.34	46.847	-1.6310
10	12.977	3094.0	-87.880	5.4525	-.31673
11	21.149	2567.1	-62.219	-2.3124	.11160
12	50.019				
R1A-300/326					
1	.00000	.00000	16362.	.00000	.00000
2	.26116	4273.1	16362.	.00000	-58142.
3	.28622	4682.2	16253.	-4360.7	11347.
4	.49362	7966.7	15908.	2699.3	-19978.
5	.67061	10756.	14986.	-7908.3	32520.
6	.82923	13064.	14932.	7566.5	-98236.
7	.88838	13953.	14796.	-9865.8	15960.
8	1.1150	16986.	12784.	987.15	-6803.3
9	1.3576				
R1B-216/241					
1	.00000	.00000	11970.	.00000	.00000
2	.19166	2294.3	11970.	.00000	-4520.4
3	.71390	7901.8	8271.7	-7082.2	1495.7
4	.96390	9550.4	5011.0	-5960.4	1484.3
5	1.2139	10454.	2309.1	-4847.2	1468.3
6	1.4639	10751.	160.84	-3746.0	1490.2
7	1.7139	10580.	-1432.7	-2623.3	1482.3
8	2.6634	8119.6	-2414.8	1593.9	-558.25
9	3.5233	6866.7	-911.91	153.78	-10.873
10	7.8435	4920.6	-191.97	12.858	-.67267
11	12.882	4193.7	-113.64	2.6907	-.32131-01
12	49.539				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R1B-243/268					
1	.00000	.00000	15795.	.00000	.00000
2	.40306	6366.2	15795.	.00000	-62372.
3	.47585	7491.9	14803.	-13621.	3355.1
4	.79835	10962.	7064.7	-10375.	3306.5
5	1.1208	12272.	1404.7	-7175.7	3287.4
6	1.3708	12226.	-1566.8	-4710.1	3077.5
7	1.6208	11588.	-3344.8	-2402.0	2983.1
8	2.0312	10017.	-3809.0	1270.8	-165.38
9	2.2962	9093.9	-3170.4	1139.4	-162.57
10	4.5260	5887.2	-514.16	51.894	-2.4042
11	11.165	4057.5	-143.02	4.0113	-.50433-01
12	48.851				
R2A-285/310					
1	.00000	.00000	12665.	.00000	.00000
2	.42416	5371.8	12665.	.00000	-16106.
3	.50065	6333.3	12382.	-3695.7	-292.45
4	1.1607	12811.	7121.3	-4274.8	-286.49
5	1.8207	15567.	1104.2	-4842.1	2408.4
6	2.0707	15578.	-865.27	-3035.8	2410.7
7	2.2207	15388.	-1613.3	-1951.0	697.97
8	3.6048	11268.	-3002.4	947.34	-144.10
9	5.4230	8074.8	-986.66	161.34	-14.372
10	8.7354	6054.4	-390.88	18.523	-.46894
11	18.977	3490.3	-159.03	4.1139	-.48391-01
12	49.546				
R2A-383/408					
1	.00000	.00000	17593.	.00000	.00000
2	.27221	4789.0	17593.	.00000	-65423.
3	.35221	6163.9	16361.	-15548.	24827.
4	.57679	9335.4	13134.	1178.3	-.13246+06
5	.61521	9834.2	12638.	-14091.	18543.
6	.85114	12275.	9085.9	-966.33	-.11809+06
7	.96237				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R2B-351/377					
1	.00000	.00000	16123.	.00000	.00000
2	.36038	5810.6	16123.	.00000	-31700.
3	.40886	6588.6	15901.	-4601.5	1275.9
4	.57786	9150.6	14455.	-3954.6	-19373.
5	.74686	11387.	11458.	-13777.	22083.
6	.91586	13036.	8693.6	-2580.4	-34126.
7	1.1930				
R2B-438/464					
1	.00000	.00000	12863.	.00000	.00000
2	.33854	4354.7	12863.	.00000	-16950.
3	.45163	5784.9	12213.	-5751.0	-76.718
4	.92163	10247.	6756.0	-5859.1	-94.990
5	1.3916	12118.	1185.4	-5993.1	3143.3
6	1.6416	12089.	-1221.7	-3635.6	3131.6
7	1.8916	11605.	-2452.4	-1286.9	982.60
8	2.9318	8767.4	-1940.1	1779.4	-1306.2
9	3.3409	8182.2	-1140.0	176.55	-12.476
10	7.6397	5553.0	-313.73	15.654	-.37944
11	19.298	3421.8	-103.45	2.3830	-.30880-01
12	48.872				
R3A-401/427					
1	.00000	.00000	15681.	.00000	.00000
2	.33875	5311.9	15681.	.00000	-56124.
3	.42536	6633.5	14418.	-14582.	4579.9
4	.76036	9999.3	6189.8	-9979.6	4662.8
5	1.0954	11128.	1073.3	-5293.4	4628.3
6	1.3454	11138.	-705.58	-1822.2	651.42
7	1.5954	10858.	-1494.5	-1333.6	660.44
8	2.6317	8611.8	-2130.8	719.65	-115.19
9	4.4671	6412.9	-653.22	85.383	-5.4565
10	9.0242	4692.9	-214.97	10.787	-.28200
11	19.571	3294.7	-81.543	1.8640	-.25512-01
12	49.360				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R3B-239/265					
1	.00000	.00000	12655.	.00000	.00000
2	.47489	6009.6	12655.	.00000	-.16678+06
3	.49773	6296.5	12394.	-11424.	3072.3
4	.85023	9380.4	5485.2	-8174.9	3151.1
5	1.2027	10436.	896.52	-4842.6	3068.7
6	1.4527	10406.	-949.42	-2541.1	3124.8
7	1.7027	10058.	-1634.1	-197.49	248.93
8	2.8097	8345.0	-1156.2	629.20	-226.07
9	3.6426	7688.0	-578.54	64.374	-3.6827
10	8.6972	5932.8	-210.03	8.5305	-.17475
11	21.377	4284.9	-77.990	1.8831	-.21884-01
12	49.168				
R3B-331/357					
1	.00000	.00000	13479.	.00000	.00000
2	.40757	5493.6	13479.	.00000	-.14541+06
3	.42843	5773.5	13289.	-9101.6	1822.9
4	.90093	10213.	5908.9	-6517.6	1846.7
5	1.3734	11745.	986.65	-3899.9	1820.5
6	1.6234	11776.	-621.96	-2534.5	1836.7
7	1.8734	11491..	-1544.8	-1157.0	918.65
8	2.4954	10303.	-1918.0	557.00	-83.688
9	4.3732	8111.6	-711.41	85.533	-5.1081
10	9.3598	6057.6	-239.43	9.1166	-.18287
11	22.580	4063.0	-94.269	1.8639	-.23413-01
12	49.133				
R4B-398/423					
1	.00000	.00000	9221.5	.00000	.00000
2	.56867	5244.0	9221.5	.00000	-49450.
3	.61213	5640.7	8941.3	-6447.1	1343.4
4	1.0671	8500.8	3908.9	-4613.3	1342.9
5	1.5221	9450.8	544.77	-2780.3	1351.0
6	1.7721	9434.3	-592.06	-1767.0	720.13
7	2.0221	9187.1	-1340.6	-1226.9	731.74
8	2.9074	7546.5	-1792.5	716.42	-150.62
9	4.2420	6072.3	-685.04	113.39	-8.7965
10	8.2890	4574.1	-199.44	6.5942	-.10332
11	24.453	2636.9	-67.247	1.5839	-.27255-01
12	48.902				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
-----	------	------	------	------	------
R4B-358/384					
1	.00000	.00000	10795.	.00000	.00000
2	.49238	5315.1	10795.	.00000	-.14256+06
3	.51400	5547.1	10595.	-9247.3	2514.1
4	.90150	8410.3	4560.7	-6324.6	2488.3
5	1.2890	9372.7	780.06	-3432.0	2528.0
6	1.5390	9392.7	-461.94	-1536.0	570.61
7	1.6890	9290.8	-884.23	-1279.2	586.20
8	2.6265	7820.5	-1737.2	369.46	-34.399
9	5.7074	4969.4	-440.19	51.518	-3.3687
10	10.023	3758.4	-183.73	7.8994	-.19789
11	20.229	2495.6	-84.332	1.8403	-.22384-01
12	48.819				
R4B-420/446					
1	.00000	.00000	13412.	.00000	.00000
2	.17819	2389.9	13412.	.00000	-.11141+06
3	.23107	3082.7	12480.	-17648.	51131.
4	.35275	4432.1	10457.	1016.9	-8296.4
5	.52964	6267.7	10038.	-3385.7	-3601.5
6	.88307	9233.4	6294.8	-7204.5	24241.
7	.99514	9882.5	5593.3	945.33	-10856.
8	1.2279	11099.	4269.1	-6635.0	2702.2
9	1.6096	11912.	384.93	-3540.6	-20727.
10	1.8423				
R5A-473/499					
1	.00000	.00000	11974.	.00000	.00000
2	.43578	5218.0	11974.	.00000	-20419.
3	.59064	6996.4	10505.	-9485.7	2542.1
4	.93814	9608.1	4833.3	-6835.6	2537.7
5	1.2856	10569.	1001.9	-4190.1	2521.7
6	1.5356	10597.	-620.30	-2298.8	2545.9
7	1.7856	10338.	-1292.3	-389.35	226.76
8	2.6949	9011.3	-1438.0	229.17	-16.839
9	6.3043	6014.9	-441.73	46.838	-2.8738
10	10.774	4719.5	-195.25	8.2999	-.16260
11	26.167	3087.6	-55.314	.79152	-.12573-01
12	49.761				

R5B-287/313

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
1	.00000	.00000	17480.	.00000	.00000
2	.25682	4489.4	17480.	.00000	-35005.
3	.30206	5276.9	17266.	-4744.5	8672.2
4	.40642	7036.9	16559.	-2029.5	-52884.
5	.48320	8272.4	15312.	-14211.	6740.2
6	.64100	10361.	11331.	-11020.	.10639+06
7	.70139	11029.	11164.	8254.7	-62271.
8	.84623	12630.	9635.7	-18805.	-.29050+06
9	.96898				

R5B-370/396

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
1	.00000	.00000	12259.	.00000	.00000
2	.32394	3971.1	12259.	.00000	-12945.
3	.56556	6750.4	9991.5	-9383.5	2437.2
4	.83806	8825.7	5420.4	-7391.1	2178.9
5	1.1106	9798.0	1877.6	-5609.9	2314.2
6	1.3606	9952.9	-493.41	-3874.3	2232.2
7	1.6106	9622.3	-2012.0	-2200.1	2276.0
8	2.2497	8031.8	-2035.1	2164.0	-1390.1
9	2.7409	7389.6	-915.36	115.77	-6.4488
10	8.1199	4811.8	-229.69	11.704	-.31598
11	18.634	3323.4	-88.364	1.7377	-.20650-01
12	49.961				

R7A-232/258

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
1	.00000	.00000	8237.0	.00000	.00000
2	.80771	6653.1	8237.0	.00000	-90672.
3	.84431	6950.6	7912.9	-8957.2	2654.8
4	1.0843	8376.3	4120.1	-6945.8	2656.1
5	1.3243	9001.7	1245.1	-5033.4	2722.9
6	1.5743	9041.0	-761.03	-2991.2	2631.7
7	1.8243	8704.9	-1763.2	-1017.5	748.78
8	2.5493	7177.1	-2057.8	611.15	-84.494
9	4.5191	4849.2	-633.61	111.83	-10.006
10	7.6629	3651.7	-227.12	17.467	-.61384
11	16.195	2604.1	-63.121	1.7543	-.23313-01
12	49.954				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R7A-295/321					
1	.00000	.00000	11932.	.00000	.00000
2	.30953	3693.3	11932.	.00000	-81122.
3	.36909	4387.7	11096.	-14267.	9706.7
4	.57353	6142.7	6479.4	-8313.9	4588.8
5	.98475	7720.4	1969.6	-2652.8	-438.62
6	1.3997	8049.6	-458.55	-3198.9	14743.
7	1.5737	7950.6	-232.44	4498.2	-20741.
8	1.8217				
R7B-175/201					
1	.00000	.00000	22998.	.00000	.00000
2	.20911	4809.1	22998.	.00000	-.96069+06
3	.23036	5289.7	21802.	-58760.	.28103+06
4	.33327				
R7B-440/466					
1	.00000	.00000	14690.	.00000	.00000
2	.50302	7389.3	14690.	.00000	-6718.4
3	.59866	8788.4	14506.	-1925.5	-3944.8
4	.97820	13801.	11340.	-6416.8	9656.2
5	1.0242	14309.	10811.	-5085.2	27.034
6	1.4582	18046.	6412.2	-5049.9	-18439.
7	1.5858				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R8A-305/331					
1	.00000	.00000	11509.	.00000	.00000
2	.27706	3188.7	11509.	.00000	-.12650+06
3	.30329	3488.3	11248.	-9955.5	2510.7
4	.61329	6093.2	5799.2	-7620.6	2565.6
5	.92329	7235.1	1814.2	-5234.3	2544.6
6	1.8233	6483.1	-1424.0	1636.3	-990.32
7	2.3233	6056.4	-530.51	150.77	-24.639
8	2.5975	5921.8	-453.39	130.50	-24.798
9	5.5440	5084.5	-330.23	-88.698	191.30
10	5.8342	4985.8	-333.38	77.843	-9.5080
11	8.4063	4481.6	-121.64	4.4767	-.60482-01
12	49.013				
R8A-384/410					
1	.00000	.00000	16696.	.00000	.00000
2	.32792	5474.8	16696.	.00000	-21964.
3	.39530	6593.1	16397.	-4434.7	-6521.4
4	.66429	10556.	12596.	-9697.3	10810.
5	.84489	12578.	10151.	-3840.6	-23412.
6	.98663	13873.	7651.0	-13796.	98852.
7	1.0312	14196.	7010.4	-568.16	-13068.
8	1.2377	15504.	5103.9	-8663.9	6576.6
9	1.5764				
R8B-300/326					
1	.00000	.00000	6673.9	.00000	.00000
2	.42013	2803.9	6673.9	.00000	-18751.
3	.48669	3242.6	6424.7	-3744.2	734.34
4	1.3367	6449.3	1651.2	-1871.7	732.80
5	2.1867	6950.6	57.708	-3.0328	-115.32
6	2.4367	6963.0	34.570	-89.528	-121.89
7	3.3107	6843.5	-401.25	-409.12	230.91
8	4.2467	6298.8	-560.24	239.26	-114.69
9	4.8083	6039.4	-400.02	46.023	-3.1248
10	8.2496	5080.4	-194.28	13.763	-.56445
11	14.867	4233.9	-86.284	2.5580	-.33687-01
12	49.097				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R8B-483/509					
1	.00000	.00000	13828.	.00000	.00000
2	.20898	2889.8	13828.	.00000	-54684.
3	.23329	3225.2	13737.	-3866.6	751.57
4	.59068	7675.1	11261.	-3060.8	-299.87
5	1.0609	12263.	8183.4	-3483.8	240.55
6	1.8089	16535.	3375.5	-2944.1	1434.3
7	2.3024	17656.	1517.6	-820.76	-1279.9
8	2.4717	17883.	1129.7	-1470.9	662.31
9	3.4310	18198.	136.23	435.26	-3364.5
10	3.7131				
R2C-196/223					
1	.00000	.00000	10108.	-11288.	16462.
2	.34526	2821.8	8200.1	5762.5	-6044.3
3	.82276	7393.2	9568.9	-2895.9	-5970.1
4	1.3003	10652.	2719.7	-11448.	7553.8
5	1.5503	10735.	-1588.0	-5782.7	7403.6
6	1.8003	10092.	-3091.2	-229.97	489.37
7	2.9205	7028.2	-1763.9	1414.7	-592.56
8	3.6721	6250.0	-641.58	78.632	-4.2502
9	8.7179	4468.7	-172.69	14.295	-.84260
10	13.399	3887.1	-94.257	2.4618	-.32331-01
11	49.990				
R2C-278/305					
1	.00000	.00000	7768.9	.00000	.00000
2	.66880	5195.8	7768.9	.00000	-85523.
3	.69040	5362.8	7649.1	-5544.2	1204.9
4	1.1579	7850.1	3255.3	-3854.3	1212.4
5	1.6254	8653.5	446.44	-2153.9	1199.5
6	1.8754	8649.2	-405.60	-1254.3	463.29
7	2.1254	8476.6	-945.87	-906.80	462.75
8	3.0368	7211.7	-1445.6	358.43	-40.387
9	5.5577	5198.2	-408.47	52.997	-3.3265
10	10.131	4120.3	-132.45	7.3550	-.19434
11	22.967	3221.0	-39.692	-.12863	.19685-01
12	49.785				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R2D-220/247					
1	.00000	.00000	10906.	.00000	.00000
2	.27280	2975.2	10906.	.00000	-49375.
3	.31217	3401.7	10678.	-5816.0	10628.
4	.50030	5275.4	9618.2	182.00	-9040.6
5	.79746	7912.4	7331.4	-7877.5	-500.56
6	1.1023	9401.1	2389.1	-8335.3	47210.
7	1.2603	9756.8	3291.4	14046.	-.36868+06
8	1.3732				
R2D-334/371					
1	.00000	.00000	8249.9	-4304.6	5886.3
2	.32427	2423.3	7315.1	1421.7	-2233.9
3	.90177	6691.6	6722.1	-2448.5	-2231.3
4	1.4793	9327.3	1661.6	-6314.2	3722.9
5	1.7293	9406.2	-797.49	-3522.0	3719.9
6	1.9793	9044.8	-1861.0	-732.12	462.67
7	3.0773	6731.2	-1795.4	791.93	-173.46
8	4.4631	5299.5	-599.12	68.175	-3.3823
9	10.429	3434.1	-146.89	7.6877	-.35343
10	14.869	2902.6	-99.521	2.9799	-.37506-01
11	49.959				
R4C-414/441					
1	.00000	.00000	10729.	.00000	.00000
2	.75713-01	812.32	10729.	.00000	-7260.0
3	.23246	2466.1	10194.	-3413.9	-300.12
4	.84246	7345.9	5693.8	-3963.1	-279.26
5	1.4525	9281.0	547.07	-4474.2	2764.6
6	1.7025	9181.4	-1171.7	-2400.7	2882.3
7	1.9525	8783.4	-1831.6	-239.01	248.20
8	3.0435	6823.0	-1466.8	573.35	-116.65
9	4.4254	5583.0	-550.48	89.738	-6.0914
10	9.2075	4336.6	-110.11	2.3499	.25179-01
11	11.907	4056.9	-96.871	2.5538	-.27488-01
12	48.897				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R4C-512/539					
1	.00000	.00000	12704.	.00000	.00000
2	.36582	4647.4	12704.	.00000	-28237.
3	.47555	6004.1	11684.	-9295.1	2160.8
4	.92555	9576.6	4631.3	-6378.0	2179.5
5	1.3755	10568.	215.13	-3435.6	2148.8
6	1.6255	10440.	-1099.8	-1824.0	972.58
7	1.8755	10067.	-1829.4	-1094.6	950.21
8	2.4500	8834.5	-2146.3	543.08	-60.721
9	5.0797	5841.9	-549.69	64.056	-3.8314
10	10.209	4190.7	-194.98	5.1042	-.78862-01
11	28.555	1844.4	-87.328	.76362	.10561
12	46.336				
R4D-495/522					
1	.00000	.00000	8843.6	.00000	.00000
2	.27951	2471.9	8843.6	.00000	-7477.7
3	.45095	3950.3	8184.2	-3845.9	-390.69
4	.87095	6680.3	4747.0	-4338.1	-383.62
5	1.2909	7880.4	899.93	-4821.5	5096.5
6	1.5409	7883.7	-555.23	-999.16	496.16
7	1.7909	7690.1	-961.78	-627.03	497.14
8	2.4653	6908.8	-1129.2	378.78	-63.574
9	4.3387	5704.8	-379.37	21.489	.15235
10	9.2109	4384.1	-159.12	23.716	-2.4221
11	11.911	4079.7	-84.027	4.0971	-.11304
12	33.501				
R6C-476/503					
1	.00000	.00000	9453.7	.00000	.00000
2	.63815	6032.9	9453.7	.00000	-14705.
3	.77505	7289.4	8627.0	-6039.2	955.85
4	1.1875	9887.5	4132.5	-4856.4	942.47
5	1.6000	10832.	607.14	-3690.1	992.45
6	1.8500	10769.	-1051.8	-2945.7	2044.2
7	2.1000	10354.	-2141.4	-1412.6	2047.7
8	2.4285	9570.4	-2406.6	605.16	-69.578
9	4.5425	6530.0	-780.82	163.90	-18.454
10	7.1537	5280.0	-302.36	19.339	-.60769
11	16.468	3650.5	-100.27	2.3587	-.30350-01
12	49.905				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R7C-143/170					
1	.00000	.00000	9405.7	.00000	.00000
2	.57869	5443.0	9405.7	.00000	-.13630+06
3	.58603	5512.0	9383.7	-3001.4	21.119
4	1.3110	10746.	5064.9	-2955.5	19.704
5	2.0360	12872.	810.54	-2912.7	1336.0
6	2.2860	12913.	-395.29	-1910.7	1318.2
7	2.5360	12716.	-1103.5	-922.03	410.53
8	3.5346	11103.	-1716.8	307.75	-25.478
9	6.9163	7831.4	-509.47	49.274	-2.5924
10	11.994	6175.4	-209.58	9.7812	-.24669
11	22.732	4747.4	-84.850	1.8342	-.20295-01
12	47.881				
R7C-541/568					
1	.00000	.00000	13009.	.00000	.00000
2	.25086	3263.4	13009.	.00000	-12550.
3	.36369	4713.1	12530.	-4248.1	-621.31
4	.83119	9578.8	8150.2	-5119.5	-587.39
5	1.2987	12210.	2978.3	-5943.4	-573.46
6	1.5487	12574.	-100.91	-6373.4	4359.7
7	1.7987	12219.	-2470.2	-3103.6	4406.8
8	2.0986	11318.	-3142.7	861.47	-103.12
9	4.3425	7438.2	-834.25	167.27	-18.869
10	6.9307	6072.4	-347.61	20.759	-.62248
11	16.425	4110.5	-121.76	3.0288	-.38002-01
12	49.814				
R7D-223/250					
1	.00000	.00000	7938.9	.00000	.00000
2	.76177	6047.6	7938.9	.00000	-38348.
3	.78959	6267.6	7849.8	-3200.5	277.86
4	1.4621	10184.	3922.1	-2639.9	284.85
5	2.1346	11714.	757.92	-2065.2	906.26
6	2.3846	11789.	-104.78	-1385.5	1148.0
7	2.4746	11769.	-326.29	-1075.6	342.08
8	3.7157	10361.	-1415.4	198.10	-13.286
9	7.2926	7224.9	-508.15	55.532	-3.8575
10	10.945	5921.6	-256.87	13.260	-.33936
11	21.556	4283.6	-90.090	2.4579	-.39452-01
12	48.930				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R7D-312/339					
1	.00000	.00000	10894.	-4959.2	16840.
2	.11484	1211.3	10422.	842.66	-1856.1
3	.84984	8589.3	8652.1	-3250.0	-1849.0
4	1.5848	12459.	878.03	-7327.0	5254.7
5	1.8348	12302.	-1800.2	-3386.0	5155.1
6	2.0848	11721.	-2526.6	480.34	-39.679
7	2.4787	10798.	-2166.8	433.46	-39.382
8	4.8014	7610.5	-790.55	159.04	-16.150
9	7.8136	6230.8	-272.07	13.094	-.30873
10	19.443	4352.1	-92.777	2.3230	-.31767-01
11	50.045				
R9A-445/482					
1	.00000	.00000	8608.1	.00000	.00000
2	.51123	4400.7	8608.1	.00000	-29070.
3	.58816	5049.7	8092.0	-6708.5	1627.3
4	1.1232	7708.0	2311.2	-4096.7	1622.8
5	1.6582	8020.4	-678.76	-1492.1	829.52
6	1.9082	7770.4	-1269.3	-869.92	844.49
7	2.1582	7411.9	-1545.9	-236.55	216.72
8	3.1812	5814.9	-1349.5	428.55	-71.233
9	4.7190	4494.1	-536.79	99.916	-11.757
10	6.7475	3718.2	-276.56	28.367	-1.6571
11	11.773	2834.4	-117.00	3.3832	-.42468-01
12	49.763				
R9B-329/356					
1	.00000	.00000	14997.	.00000	.00000
2	.19047	2856.5	14997.	.00000	-.39456+06
3	.21750	3254.6	14176.	-31189.	.10131+06
4	.34312	4744.0	11136.	6991.6	-47892.
5	.43860	5829.2	11161.	-6726.0	6730.2
6	.56422	7138.5	9789.8	-4189.5	14588.
7	.70593	8483.2	9481.2	2012.0	-65730.
8	.89587				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R9C-332/359					
1	.00000	.00000	7337.4	.00000	.00000
2	.59555	4369.7	7337.4	.00000	-20008.
3	.66254	4855.3	7067.9	-4021.5	676.08
4	1.2025	7605.8	3316.2	-2926.2	671.77
5	1.7425	8649.0	743.57	-1838.0	480.08
6	1.9925	8727.6	-85.388	-1477.9	454.78
7	2.2425	8621.0	-739.06	-1136.8	467.16
8	3.3869	6986.8	-1505.7	466.81	-85.430
9	4.6330	5670.0	-740.19	147.40	-14.717
10	7.4114	4435.7	-261.93	24.733	-1.1605
11	13.970	3454.4	-87.253	1.9008	-.21187-01
12	49.998				
R9D-249/276					
1	.00000	.00000	8628.7	.00000	.00000
2	.54229	4679.3	8628.7	.00000	-27198.
3	.59164	5101.8	8430.0	-4026.6	129.74
4	1.0891	8315.1	4519.9	-3832.9	123.04
5	1.5866	9630.3	797.54	-3649.3	2007.7
6	1.8366	9632.9	-650.67	-2143.5	2056.5
7	1.9866	9494.0	-1154.9	-1218.1	565.57
8	2.9718	7714.7	-1908.2	453.48	-46.144
9	5.7191	4938.1	-461.40	73.170	-9.2132
10	7.9022	4183.7	-273.66	12.829	-.33085
11	16.165	2611.8	-129.42	4.6280	-.60953-01
12	49.877				
R10A-269/296					
1	.00000	.00000	11899.	.00000	.00000
2	.14121	1680.3	11899.	.00000	-14727.
3	.20416	2425.7	11724.	-2781.0	-408.37
4	.93416	9343.5	7011.0	-3675.4	-405.58
5	1.6642	12345.	996.59	-4563.6	2448.7
6	1.9142	12347.	-826.07	-2727.1	2482.6
7	2.1642	12009.	-1724.1	-865.14	538.11
8	3.1763	9935.8	-1821.7	768.71	-165.39
9	4.6076	8418.2	-637.66	58.512	-2.4154
10	11.858	5950.2	-170.13	5.9769	-.97364-01
11	31.005	4200.5	-48.329	.38406	.12179-02
12	50.044				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R10B-274/301					
1	.00000	.00000	11715.	.00000	.00000
2	.24892	2916.1	11715.	.00000	-84243.
3	.26206	3069.8	11671.	-3320.3	-256.21
4	.99706	9752.7	6375.2	-3885.2	-259.12
5	1.7321	12237.	243.98	-4456.6	2904.2
6	1.9821	12065.	-1439.8	-2278.4	2943.9
7	2.2321	11608.	-2027.0	-70.498	181.85
8	3.2861	9606.4	-1569.5	504.51	-79.915
9	5.2205	7879.6	-514.80	40.735	-1.6019
10	11.815	5796.8	-186.54	9.0424	-.31877
11	18.285	4882.1	-109.56	2.8555	-.34683-01
12	48.472				
R10C-445/472					
1	.00000	.00000	13794.	.00000	.00000
2	.27464	3788.2	13794.	.00000	-44595.
3	.34761	4777.6	13085.	-9738.8	6895.0
4	.66881	8204.1	8962.5	-3095.0	-35646.
5	.77391	9070.5	7130.5	-14334.	40178.
6	.80699	9292.1	6314.2	-10347.	7509.0
7	1.0581	10344.	2537.9	-4690.2	-44162.
8	1.2112				
R10D-231/258					
1	.00000	.00000	10988.	.00000	.00000
2	.76532-01	840.97	10988.	.00000	-4611.6
3	.26207	2850.3	10512.	-2566.9	-446.66
4	.93207	8606.8	6470.9	-3464.7	-447.07
5	1.6021	11253.	1226.1	-4363.3	1594.0
6	1.8521	11311.	-656.65	-3167.9	1572.0
7	2.1021	10974.	-1945.8	-1988.9	1583.1
8	2.7110	9408.7	-2606.9	903.25	-144.74
9	4.5342	6781.0	-756.74	111.58	-7.9788
10	8.6160	5008.6	-244.62	13.880	-.43214
11	18.195	3559.3	-97.652	1.4624	-.14985-01
12	49.957				

STRAIN RATE = (10E-3)/SEC
TEMPERATURE = -20°C

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R1C-127/154					
1	.00000	.00000	15424.	.00000	.00000
2	.20742	3199.2	15424.	.00000	-.14299+06
3	.24842	3821.9	14709.	-17509.	50391.
4	.45492	6556.4	13924.	13708.	-46173.
5	.66142	9609.7	13679.	-14896.	30937.
6	.86792	12072.	11484.	4269.3	-13438.
7	1.2522	16353.	8811.7	-11223.	92984.
8	1.3207	16933.	8582.3	7873.1	-44615.
9	1.6196				
R1D-153/178					
1	.00000	.00000	17526.	.00000	.00000
2	.26357	4619.3	17526.	.00000	-18774.
3	.37483	6543.9	16839.	-6219.0	15457.
4	.45373	7841.4	16147.	-2560.3	-3082.1
5	.64540	10821.	14825.	-4332.6	43965.
6	.73566	12156.	15118.	7572.4	-.18059+06
7	.76407	12587.	15111.	-7816.2	11147.
8	.97973				
R2C-129/156					
1	.00000	.00000	9968.2	.00000	.00000
2	.95951	9564.6	9968.2	.00000	-2054.3
3	1.1756	11699.	9688.0	-1314.2	-1197.9
4	1.4763	14460.	8573.0	-2394.6	1465.5
5	1.7769	16861.	7530.6	-1072.8	-4198.8
6	2.2699				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R2D-095/122					
1	.00000	.00000	15185.	.00000	.00000
2	.42113	6395.0	15185.	.00000	-36491.
3	.46863	7112.7	14950.	-5076.6	32.327
4	.77716	11243.	11827.	-5046.6	-2864.1
5	1.0104	13691.	9004.7	-7051.2	-338.85
6	1.0782	14268.	8044.9	-7120.2	1046.1
7	1.3415				
R4D-198/225					
1	.00000	.00000	13065.	.00000	.00000
2	.71293	9314.8	13065.	.00000	-.11786+06
3	.74238	9696.6	12761.	-10372.	26094.
4	.91175	11687.	11493.	2886.7	-15666.
5	1.1895				
R6A-531/558					
1	.00000	.00000	18705.	.00000	.00000
2	.28760	5379.5	18705.	.00000	-.33034+06
3	.29910	5594.1	18574.	-11397.	2191.2
4	.89660	13091.	7301.7	-7468.9	2193.2
5	1.4941	15255.	725.30	-3537.6	1044.2
6	1.7441	15231.	-847.71	-2754.4	1029.5
7	1.9941	14863.	-2031.9	-1982.3	1037.0
8	2.8800	12228.	-3102.6	773.71	-79.976
9	5.4626	7998.6	-706.54	154.09	-35.717
10	6.5374	7372.8	-499.09	38.923	-1.4465
11	14.566	5126.2	-153.81	4.0844	-.55343-01
12	47.904				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
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R6C-134/161					
1	.00000	.00000	14187.	.00000	.00000
2	.38191	5418.1	14187.	.00000	-7939.5
3	.59341	8344.6	13132.	-5012.0	1284.4
4	.80654	10928.	11171.	-4190.8	-1028.1
5	1.2321	14844.	7044.9	-5503.4	-7561.6
6	1.3463	15565.	5493.4	-8092.1	15693.
7	1.5823				
R7C-092/119					
1	.00000	.00000	15162.	.00000	.00000
2	.59584	9034.1	15162.	.00000	-98618.
3	.60749	9210.6	15122.	-3448.2	-636.72
4	1.4375	19022.	8082.0	-5033.6	568.28
5	2.0735	22272.	2368.5	-3949.2	37.943
6	2.5299	22534.	-1212.8	-3897.3	848.92
7	2.9836	21261.	-4224.7	-2741.9	2082.7
8	3.6311	17942.	-5156.0	1303.6	-133.45
9	6.5724	10658.	-950.79	126.11	-10.408
10	11.848	7624.2	-489.20	-38.623	466.72
11	12.398	7421.1	-107.30	732.25	-213.05
12	16.437				
R7D-036/063					
1	.00000	.00000	13503.	.00000	.00000
2	.33875	4574.1	13503.	.00000	-17867.
3	.35734	4825.1	13489.	-881.14	-6323.3
4	.56369	7515.4	12317.	-4795.3	26855.
5	.62862	8302.4	12034.	436.49	-2967.2
6	1.1649	14424.	9942.2	-4337.8	17780.
7	1.2299	15057.	9603.8	-874.27	-3600.9
8	1.5305	17767.	8101.8	-4121.8	706.50
9	1.8966	20215.	5368.1	-3345.9	-1371.8
10	2.3241				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
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R9A-071/098					
1	.00000	.00000	10160.	.00000	.00000
2	.31759	3226.8	10160.	.00000	-1505.5
3	.48565	4927.3	10033.	-759.08	-912.80
4	1.5047	13397.	5641.9	-3549.7	-186.02
5	2.5238	15263.	-2172.5	-4118.4	3441.8
6	2.8210	14344.	-3708.5	-1049.5	1385.1
7	3.1891	12906.	-3918.1	479.86	358.66
8	3.7342	10971.	-3075.2	1066.4	-179.52
9	5.2381	8147.5	-1085.7	256.45	-33.771
10	7.2465	6727.8	-464.27	52.970	-4.3987
11	10.236	5695.7	-265.49	13.517	-.46847
12	26.146				
R9B-076/103					
1	.00000	.00000	9437.1	-1768.9	965.34
2	.44817	3961.0	8433.2	-471.04	-588.11
3	1.3682	10863.	6073.2	-2094.2	-591.76
4	2.2882	14217.	717.20	-3727.5	890.93
5	2.5382	14177.	-979.48	-3059.3	869.52
6	2.7882	13755.	-2346.1	-2407.1	1516.3
7	3.5493	11243.	-3375.1	1055.3	-134.73
8	5.9819	7337.7	-632.95	72.002	-3.7883
9	11.638	5375.6	-182.02	7.7186	-.19082
10	37.777	2483.5	-169.64	-7.2448	.90772
11	49.938				
R9C-049/076					
1	.00000	.00000	11624.	.00000	.00000
2	.43356	5039.8	11624.	.00000	-70148.
3	.44374	5158.1	11602.	-2143.1	-127.23
4	1.4087	14244.	7110.8	-2511.5	-132.06
5	2.3737	18649.	1894.7	-2893.8	-102.00
6	2.6237	18940.	428.70	-2970.3	-147.65
7	2.8737	18859.	-1084.1	-3081.0	970.63
8	4.3687	13596.	-3788.3	1272.2	-190.63
9	6.1705	9785.2	-1060.3	241.86	-32.215
10	8.2007	8360.0	-476.56	45.655	-2.2018
11	14.510	6617.6	-163.41	3.9784	-.57510-01
12	49.849				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R9D-150/177					
1	.00000	.00000	16460.	.00000	.00000
2	.35467	5838.1	16460.	.00000	-64074.
3	.38450	6327.3	16289.	-5733.3	499.82
4	1.3370	17073.	6727.8	-4305.1	490.38
5	2.2895	19999.	-138.70	-2903.8	-633.90
6	2.5395	19773.	-1709.5	-3379.3	-705.46
7	2.7895	19124.	-3531.4	-3908.4	1848.4
8	4.1772	11637.	-3700.4	3786.6	-1561.4
9	5.0328	10264.	-649.86	-221.36	147.74
10	5.6624	9804.4	-752.92	57.663	-1.9093
11	15.106	6228.6	-174.67	3.5718	-.35090-01
12	49.805				
R10A-238/265					
1	.00000	.00000	11110.	.00000	.00000
2	.54192	6020.5	11110.	.00000	-658.70
3	.61657	6849.5	11099.	-147.06	-1151.5
4	1.1672	12724.	9889.4	-2049.1	-373.78
5	1.7178	17486.	7292.8	-2666.6	139.72
6	2.2684	20716.	4483.4	-2435.8	171.78
7	3.1981	22917.	399.99	-1956.7	253.83
8	3.7407	22598.	-1499.2	-1543.5	984.45
9	4.2727				
R10B-084/111					
1	.00000	.00000	17492.	.00000	.00000
2	.80659-01	1410.8	17492.	.00000	-8270.4
3	.30241	5199.4	16272.	-5501.8	359.01
4	1.1524	15276.	7696.7	-4586.3	359.60
5	2.0024	18725.	679.37	-3669.3	1452.7
6	2.2524	18688.	-882.91	-2579.8	1460.7
7	2.5024	18329.	-1898.9	-1484.2	512.44
8	4.1191	13545.	-2679.9	1001.1	-213.29
9	5.3895	11319.	-1168.9	188.21	-15.398
10	8.7778	8920.2	-423.83	31.688	-1.4869
11	14.852	7181.7	-203.44	4.5920	-.83864-01
12	49.842				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R1C-349/375					
1	.00000	.00000	19693.	.00000	.00000
2	.23141	4557.1	19693.	.00000	-74804.
3	.27228	5357.4	19338.	-8925.9	-1651.3
4	.39791	7642.7	17018.	-9548.3	3366.7
5	.87017	13904.	10252.	-4778.4	-562.25
6	1.0091	15235.	8891.8	-5012.7	-4574.2
7	1.3702	17577.	3481.5	-9968.5	22611.
8	1.5647	18043.	2169.7	3222.7	-76763.
9	1.7036				
R1C-384/410					
1	.00000	.00000	17297.	.00000	.00000
2	.17142	2964.9	17297.	.00000	-.17383+06
3	.18399	3182.1	17215.	-6531.8	-14842.
4	.27600	4699.0	15636.	-10628.	41349.
5	.34558	5749.5	14757.	-1997.1	-9514.5
6	.61585	9404.3	11593.	-9711.8	37299.
7	.69777	10309.	10753.	-544.70	-11840.
8	.84781	11870.	9789.5	-5873.9	-.10171+06
9	.95574				
R1D-179/206					
1	.00000	.00000	14819.	.00000	.00000
2	.48388	7170.6	14819.	.00000	-15620.
3	.50060	7418.2	14806.	-779.65	-20000.
4	.55060	8154.1	14578.	-3780.0	2095.5
5	.85554	12307.	12857.	-1863.1	-1633.4
6	1.0951	15258.	11683.	-3036.9	3595.7
7	1.3056	17616.	10883.	-765.81	-13006.
8	1.6248				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R1D-285/312					
1	.00000	.00000	21439.	.00000	.00000
2	.24995	5358.8	21439.	.00000	-50981.
3	.35286	7509.7	19823.	-15722.	.13772+06
4	.40695	8557.7	19331.	6626.1	-40693.
5	.55720	11474.	18566.	-11716.	30674.
6	.70745	14103.	17123.	2110.1	-18037.
7	.95386	18180.	14877.	-11223.	83284.
8	1.1041				
R2C-226/253					
1	.00000	.00000	10609.	.00000	.00000
2	.83647	8873.8	10609.	.00000	-5103.6
3	.97889	10370.	10298.	-2180.5	-571.60
4	1.6764	16298.	6422.0	-3376.6	-586.86
5	2.3739	18936.	855.20	-4604.6	1474.2
6	2.6239	18885.	-1170.7	-3498.9	1405.9
7	2.8739	18395.	-2656.5	-2444.5	1436.7
8	3.6134	15675.	-3914.8	743.09	-56.499
9	7.6515	8263.4	-677.26	58.652	-2.5959
10	13.914	5684.8	-248.08	9.8847	-.16915
11	33.728	3334.3	-55.590	-.17016	.56329-01
12	49.804				
R2C-310/337					
1	.00000	.00000	8697.4	.00000	.00000
2	.56881	4947.2	8697.4	.00000	-11870.
3	.63354	5506.9	8548.2	-2304.9	-8.7090
4	1.7917	12302.	3174.1	-2335.2	446.11
5	2.6654	13590.	115.22	-1165.9	293.68
6	3.7835	12672.	-1390.5	-180.95	-1440.2
7	3.8547	12572.	-1438.1	-488.65	248.56
8	4.8024	10981.	-1694.6	218.04	-11.461
9	12.029	5796.8	-338.81	-30.434	69.620
10	14.072	5571.2	408.42	396.31	-3996.2
11	14.208	5624.0	294.02	-1236.3	485.71
12	16.379				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
-----	------	------	------	------	------
R2D-265/292					
1	.00000	.00000	11546.	.00000	.00000
2	.61301	7078.0	11546.	.00000	-16119.
3	.77420	8874.8	10330.	-7670.7	39738.
4	.83913	9524.1	9836.3	70.663	-3497.8
5	1.1398	12392.	8930.4	-3083.9	312.93
6	1.6049	15910.	6264.9	-2647.3	78.960
7	1.9334				
R2D-406/433					
1	.00000	.00000	9040.9	.00000	.00000
2	.80577	7284.9	9040.9	.00000	-.11201+06
3	.81529	7370.8	9010.5	-3196.1	119.14
4	1.5503	12314.	4505.3	-2933.4	120.94
5	2.2853	14089.	389.28	-2666.7	900.85
6	2.5353	14034.	-775.16	-1991.1	912.52
7	2.7853	13730.	-1599.6	-1306.7	577.65
8	3.8313	11288.	-2437.1	506.03	-48.917
9	6.4921	7464.2	-783.22	115.57	-9.8071
10	9.9585	5729.4	-335.53	13.580	-.23370
11	29.625	2605.5	-72.542	-.20755	.39238-01
12	49.815				
R4C-482/509					
1	.00000	.00000	13422.	.00000	.00000
2	.56178	7540.3	13422.	.00000	-17186.
3	.65799	8816.3	12945.	-4960.4	331.25
4	1.3655	15609.	6423.2	-4257.4	335.16
5	2.0730	18141.	902.39	-3546.0	2138.3
6	2.3230	18179.	-469.66	-1942.2	491.37
7	2.5730	17947.	-1348.6	-1573.7	491.98
8	4.0319	14158.	-2799.0	579.57	-53.546
9	6.9780	9573.1	-778.34	106.31	-7.8102
10	10.838	7703.5	-306.77	15.869	-.40720
11	22.351	5653.7	-103.28	1.8050	-.17558-01
12	48.813				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R4C-543/570					
1	.00000	.00000	9995.6	.00000	.00000
2	.20195-01	201.86	9995.6	.00000	-306.61
3	.52418	5200.2	9761.9	-463.58	-719.77
4	1.5642	14042.	6462.2	-2709.3	74.345
5	2.6042	17915.	1068.1	-2477.3	-3527.9
6	2.8542	17973.	-832.02	-5123.2	2771.3
7	3.1042	17488.	-2874.0	-3044.7	2789.2
8	3.5403	15886.	-3938.1	604.99	32.495
9	4.6385	12334.	-2491.8	712.05	-108.99
10	6.4343	9524.5	-988.83	124.88	-7.7093
11	11.328	6772.7	-320.46	11.702	-.19697
12	44.104				
R4D-382/409					
1	.00000	.00000	10095.	.00000	.00000
2	.19895	2008.4	10095.	.00000	-693.95
3	.80075	7932.3	9340.9	-1252.9	-415.84
4	1.7158	15112.	6003.7	-2394.4	-413.74
5	2.6308	18284.	582.86	-3530.1	1999.6
6	2.8808	18240.	-807.26	-2030.4	2025.7
7	3.1308	17943.	-1442.6	-511.10	111.69
8	3.6204	17127.	-1862.8	-347.02	111.60
9	5.6329	12882.	-1903.7	326.74	-25.879
10	9.3245	9005.6	-549.25	40.136	-1.4367
11	17.473	6417.7	-181.33	5.0148	-.74296-01
12	49.866				
R4D-414/441					
1	.00000	.00000	18363.	.00000	.00000
2	.22846	4195.3	18363.	.00000	-78332.
3	.22854	4196.7	18363.	-1.5284	-14896.
4	.42916	7760.4	16564.	-8967.2	632.97
5	.62979	10728.	13042.	-8586.2	9778.6
6	.83041	13078.	10778.	-2700.7	-10024.
7	1.1374	15842.	6285.3	-11933.	23066.
8	1.3601				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R4D-525/552					
1	.00000	.00000	11146.	.00000	.00000
2	.27825	3101.4	11146.	.00000	-31757.
3	.29870	3329.1	11107.	-1923.3	313.13
4	.59933	6502.9	10036.	-1640.9	-437.92
5	1.2374	12125.	7406.7	-2479.2	-3909.2
6	1.4551	13579.	5772.0	-5031.6	12602.
7	1.5483	14084.	5162.5	-1509.0	-1102.2
8	2.1145	16323.	2393.7	-3381.2	6222.4
9	2.2949				
R6C-559/586					
1	.00000	.00000	13111.	.00000	.00000
2	.22896	3002.0	13111.	.00000	-26133.
3	.26104	3421.8	13031.	-2515.3	-221.60
4	1.3360	14248.	6854.4	-3230.0	225.56
5	2.4110	18164.	691.93	-2502.6	-80.653
6	2.6610	18179.	-574.48	-2563.1	-103.58
7	2.9110	17873.	-1875.4	-2640.7	1297.3
8	3.8041	15016.	-3488.2	834.87	-88.273
9	6.4630	9984.6	-920.70	130.74	-12.757
10	8.4980	8544.9	-547.07	52.862	-2.9173
11	13.814	6692.4	-232.37	6.3410	-.86018-01
12	48.036				
R7C-457/484					
1	.00000	.00000	10661.	.00000	.00000
2	1.0166	10838.	10661.	.00000	-35104.
3	1.0460	11151.	10570.	-3095.2	131.33
4	1.8810	17895.	5675.6	-2766.2	131.73
5	2.7160	20782.	1331.5	-2436.3	596.52
6	2.9660	20972.	225.19	-1988.9	609.25
7	3.2160	20913.	-655.02	-1531.9	320.35
8	4.6160	17873.	-3060.8	-186.47	346.22
9	5.2792	15862.	-2851.3	502.35	-37.862
10	9.3634	10017.	-642.61	38.448	-1.1430
11	19.478	6267.7	-215.66	3.7657	-.52005-01
12	49.926				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R7C-572/599					
1	.00000	.00000	13295.	.00000	.00000
2	.21366	2840.6	13295.	.00000	-50299.
3	.22049	2931.4	13289.	-976.66	1092.1
4	.39791	5264.4	13045.	-395.36	-1447.8
5	.76103	9879.9	12185.	-1972.5	-588.26
6	1.5754	18177.	7802.4	-3409.6	346.42
7	1.9036	20383.	5676.2	-3068.5	-2932.1
8	2.1794	21654.	3314.1	-5494.9	7085.1
9	2.3243	22040.	2167.8	-2414.5	-2235.7
10	2.8091				
R7D-254/281					
1	.00000	.00000	8822.9	.00000	.00000
2	.88542	7812.0	8822.9	.00000	-24618.
3	.91784	8097.2	8745.3	-2394.9	73.209
4	1.8553	14251.	4447.8	-2189.0	94.898
5	2.7928	16575.	593.62	-1922.1	513.35
6	3.0428	16612.	-271.18	-1537.1	507.39
7	3.8064	15734.	-1731.0	-374.86	263.84
8	4.5766	14299.	-1838.8	234.83	-15.519
9	7.3944	10635.	-885.11	103.64	-5.8033
10	12.661	8000.6	-276.31	11.948	-.25348
11	26.501	5793.3	-91.233	1.4242	.19753-01
12	49.858				
R7D-546/573					
1	.00000	.00000	12052.	.00000	.00000
2	.21371	2575.7	12052.	.00000	-1673.9
3	.50782	6077.6	11618.	-1476.9	-573.61
4	1.4803	15451.	7117.5	-3150.4	-580.68
5	2.4528	18860.	-657.49	-4844.5	3447.3
6	2.7028	18446.	-2433.4	-2259.0	3385.0
7	2.9528	17750.	-2928.2	279.74	-3.2418
8	3.4429	16382.	-2656.4	274.98	-3.2595
9	5.1974	12550.	-1721.5	257.82	-16.690
10	9.9817	8387.0	-400.69	18.261	-.43738
11	20.551	5675.6	-161.25	4.3932	-.69699-01
12	49.898				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R9A-424/451					
1	.00000	.00000	11926.	.00000	.00000
2	.49370	5887.7	11926.	.00000	-20042.
3	.59830	7112.7	11276.	-6252.5	3551.6
4	.82931	9427.5	8955.4	-3791.1	19893.
5	.91588	10187.	8746.3	1375.3	-20339.
6	1.0614	11427.	7853.7	-7507.1	7448.9
7	1.4962	14035.	5550.0	2208.7	-87703.
8	1.6241				
R9B-417/444					
1	.00000	.00000	10820.	.00000	.00000
2	.27414	2966.1	10820.	.00000	-32293.
3	.33739	3642.9	10453.	-5959.2	8504.5
4	.66301	6708.6	9277.7	2348.7	-6360.0
5	.98864	9759.1	8784.2	-3864.3	2201.4
6	1.4813	13412.	6579.6	-610.83	-2147.1
7	1.8952	15878.	4970.4	-3276.9	1690.7
8	1.9655	16212.	4534.5	-2920.2	-436.07
9	2.4995				
R9C-507/534					
1	.00000	.00000	14191.	.00000	.00000
2	.28820	4090.0	14191.	.00000	-24625.
3	.33186	4707.5	14051.	-3225.0	-409.52
4	1.1569	13874.	7893.2	-4238.6	-412.54
5	1.9819	17270.	57.182	-5259.6	2337.8
6	2.2319	16992.	-2134.3	-3506.3	1773.8
7	2.4819	16267.	-3554.8	-2175.9	1757.4
8	3.1503	13443.	-4108.1	1348.1	-189.81
9	5.0559	9196.7	-1038.1	262.94	-39.675
10	6.8977	7928.9	-473.28	43.724	-1.8715
11	13.900	6116.1	-136.24	4.4086	-.64839-01
12	49.862				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R9D-348/375					
1	.00000	.00000	57896.	.00000	.00000
2	.61571-01	3564.7	57896.	.00000	-.10446+08
3	.69371-01	4011.7	56096.	-.23756+06	.27827+07
4	.10310	5740.1	49568.	43976.	-.78727+06
5	.19362	10004.	38175.	-.16982+06	.23075+07
6	.22025	10943.	34039.	14487.	.24923+06
7	.27664	12954.	38052.	56656.	-.94038+07
8	.29468	13603.	30918.	-.45216+06	.53001+07
9	.35337				
R10A-407/434					
1	.00000	.00000	10017.	.00000	.00000
2	.67403	6751.6	10017.	.00000	-15095.
3	.69667	6978.2	9993.6	-1025.0	-621.75
4	1.6117	14788.	6556.2	-2731.7	-250.75
5	2.5267	18308.	927.46	-3420.0	1545.7
6	2.7767	18350.	-492.72	-2260.7	753.02
7	3.0267	18097.	-1481.9	-1696.0	752.20
8	4.0839	15524.	-2545.7	689.69	-126.09
9	5.1662	13417.	-1495.9	280.28	-26.339
10	7.9568	10852.	-546.99	59.768	-4.4782
11	11.837	9368.2	-285.44	7.6436	-.92936-01
12	48.827				
R10B-449/476					
1	.00000	.00000	11552.	.00000	.00000
2	.73718	8515.6	11552.	.00000	-15593.
3	.79651	9197.7	11387.	-2775.5	-478.26
4	1.4690	15455.	7005.0	-3740.4	-479.90
5	2.1415	18328.	1323.0	-4708.6	1241.2
6	2.3915	18384.	-798.56	-3777.7	1265.3
7	2.6415	17968.	-2450.2	-2828.8	1252.2
8	3.7829	13348.	-4013.6	1459.0	-236.00
9	5.3678	9712.2	-1167.4	336.87	-55.483
10	7.1226	8401.1	-497.69	44.781	-2.0386
11	13.820	6464.3	-172.18	3.8248	-.41906-01
12	49.902				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R10C-506/533					
1	.00000	.00000	9519.6	.00000	.00000
2	.21668	2062.7	9519.6	.00000	-286.05
3	.50843	4833.0	9446.6	-250.37	-947.68
4	1.3134	11781.	7201.1	-2539.0	-954.48
5	2.1184	15434.	1257.7	-4844.1	2533.3
6	2.3684	15486.	-689.38	-2944.2	2440.0
7	2.6184	15167.	-1704.0	-1114.2	508.52
8	3.8884	12248.	-2073.5	823.24	-201.44
9	5.1030	10583.	-965.22	89.245	-3.8761
10	11.282	7112.0	-306.30	17.396	-.75651
11	16.979	5791.6	-181.75	4.4648	-.53429-01
12	49.973				
R10D-508/535					
1	.00000	.00000	15696.	.00000	.00000
2	.23855	3744.4	15696.	.00000	-26915.
3	.31062	4865.6	15277.	-5819.5	511.15
4	1.1056	13590.	6993.1	-4600.4	509.96
5	1.9006	16498.	645.35	-3384.2	1327.5
6	2.1506	16468.	-797.84	-2388.6	1351.5
7	2.4006	16141.	-1738.7	-1374.9	607.70
8	3.5626	13217.	-2472.4	743.53	-130.47
9	5.1325	10664.	-1102.5	129.06	-6.9359
10	10.371	7432.8	-321.35	20.071	-1.1062
11	14.871	6292.3	-207.92	5.1373	-.66725-01
12	49.861				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R1C-127/154					
1	.00000	.00000	15424.	.00000	.00000
2	.20742	3199.2	15424.	.00000	-.14299+06
3	.24842	3821.9	14709.	-17509.	50391.
4	.45492	6556.4	13924.	13708.	-46173.
5	.66142	9609.7	13679.	-14896.	30937.
6	.86792	12072.	11484.	4269.3	-13438.
7	1.2522	16353.	8811.7	-11223.	92984.
8	1.3207	16933.	8582.3	7873.1	-44615.
9	1.6196				
R1D-153/178					
1	.00000	.00000	17526.	.00000	.00000
2	.26357	4619.3	17526.	.00000	-18774.
3	.37483	6543.9	16839.	-6219.0	15457.
4	.45373	7841.4	16147.	-2560.3	-3082.1
5	.64540	10821.	14825.	-4332.6	43965.
6	.73566	12156.	15118.	7572.4	-.18059+06
7	.76407	12587.	15111.	-7816.2	11147.
8	.97973				
R2C-129/156					
1	.00000	.00000	9968.2	.00000	.00000
2	.95951	9564.6	9968.2	.00000	-2054.3
3	1.1756	11699.	9688.0	-1314.2	-1197.9
4	1.4763	14460.	8573.0	-2394.6	1465.5
5	1.7769	16861.	7530.6	-1072.8	-4198.8
6	2.2699				

I	T(I)	Y(I)	C(I,1)	C(I,2)	C(I,3)
R2D-095/122					
1	.00000	.00000	15185.	.00000	.00000
2	.42113	6395.0	15185.	.00000	-36491.
3	.46863	7112.7	14950.	-5076.6	32.327
4	.77716	11243.	11827.	-5046.6	-2864.1
5	1.0104	13691.	9004.7	-7051.2	-338.85
6	1.0782	14268.	8044.9	-7120.2	1046.1
7	1.3415				
R4D-198/225					
1	.00000	.00000	13065.	.00000	.00000
2	.71293	9314.8	13065.	.00000	-.11786+06
3	.74238	9696.6	12761.	-10372.	26094.
4	.91175	11687.	11493.	2886.7	-15666.
5	1.1895				
R6A-531/558					
1	.00000	.00000	18705.	.00000	.00000
2	.28760	5379.5	18705.	.00000	-.33034+06
3	.29910	5594.1	18574.	-11397.	2191.2
4	.89660	13091.	7301.7	-7468.9	2193.2
5	1.4941	15255.	725.30	-3537.6	1044.2
6	1.7441	15231.	-847.71	-2754.4	1029.5
7	1.9941	14863.	-2031.9	-1982.3	1037.0
8	2.8800	12228.	-3102.6	773.71	-79.976
9	5.4626	7998.6	-706.54	154.09	-35.717
10	6.5374	7372.8	-499.09	38.923	-1.4465
11	14.566	5126.2	-153.81	4.0844	-.55343-01
12	47.904				

THE UNIAXIAL MECHANICAL RESPONSE OF MULTI-RIDGE ICE

VOLUME IV
APPENDIX C - STRESS-STRAIN CURVES

BY

J. F. DORRIS AND J. S. AUSTIN

TECHNICAL PROGRESS REPORT

BRC 45-85
OCTOBER 1985

Project No. 327-27802.34
Mechanical Properties of Sea Ice

Reviewed by: E.G. Ward
E.N. Earle
Participant: C.A. Gutierrez
Released by: J.H. Lybarger
Reference: Based on work through December 1983.

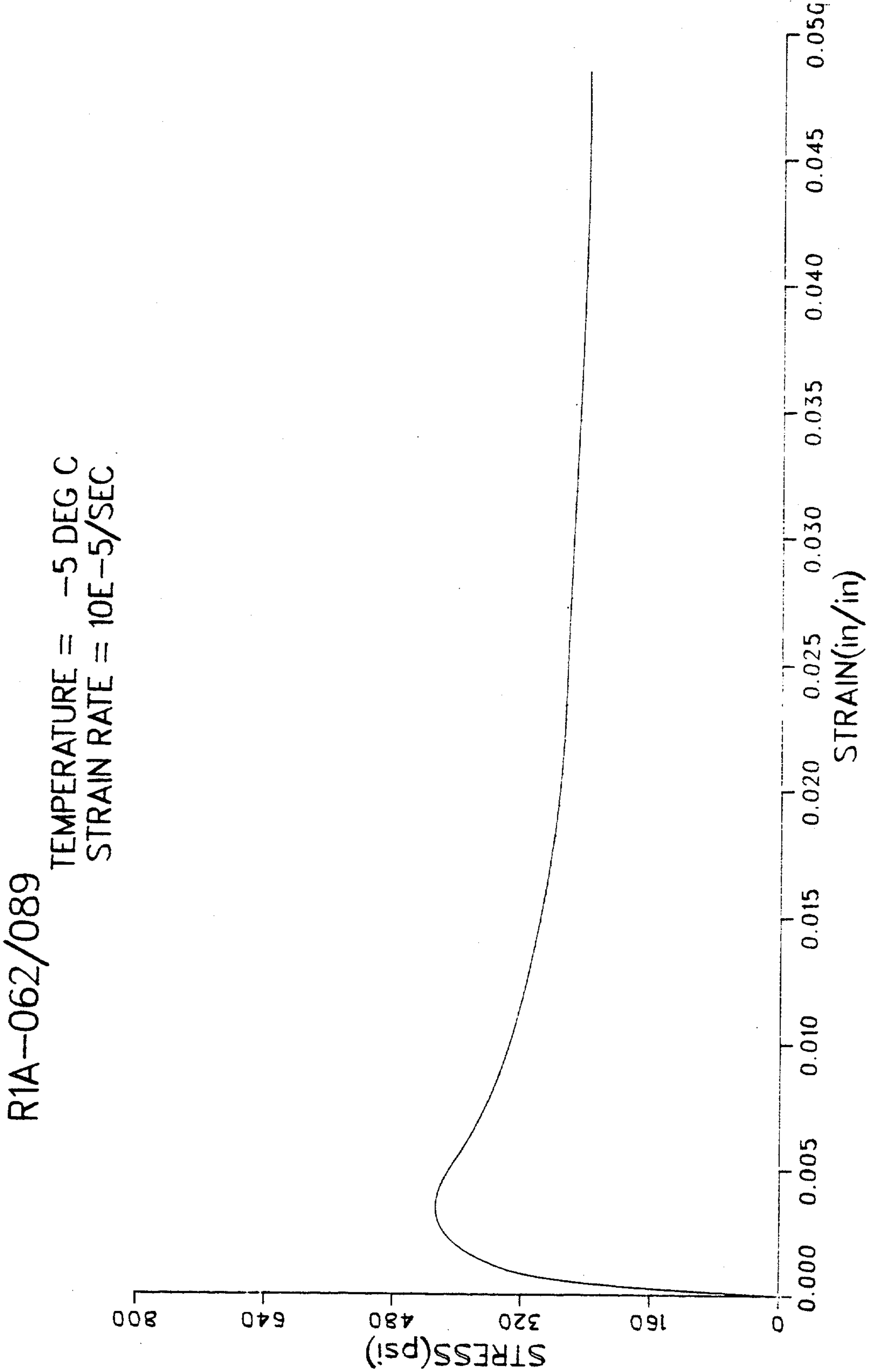
Appendix C

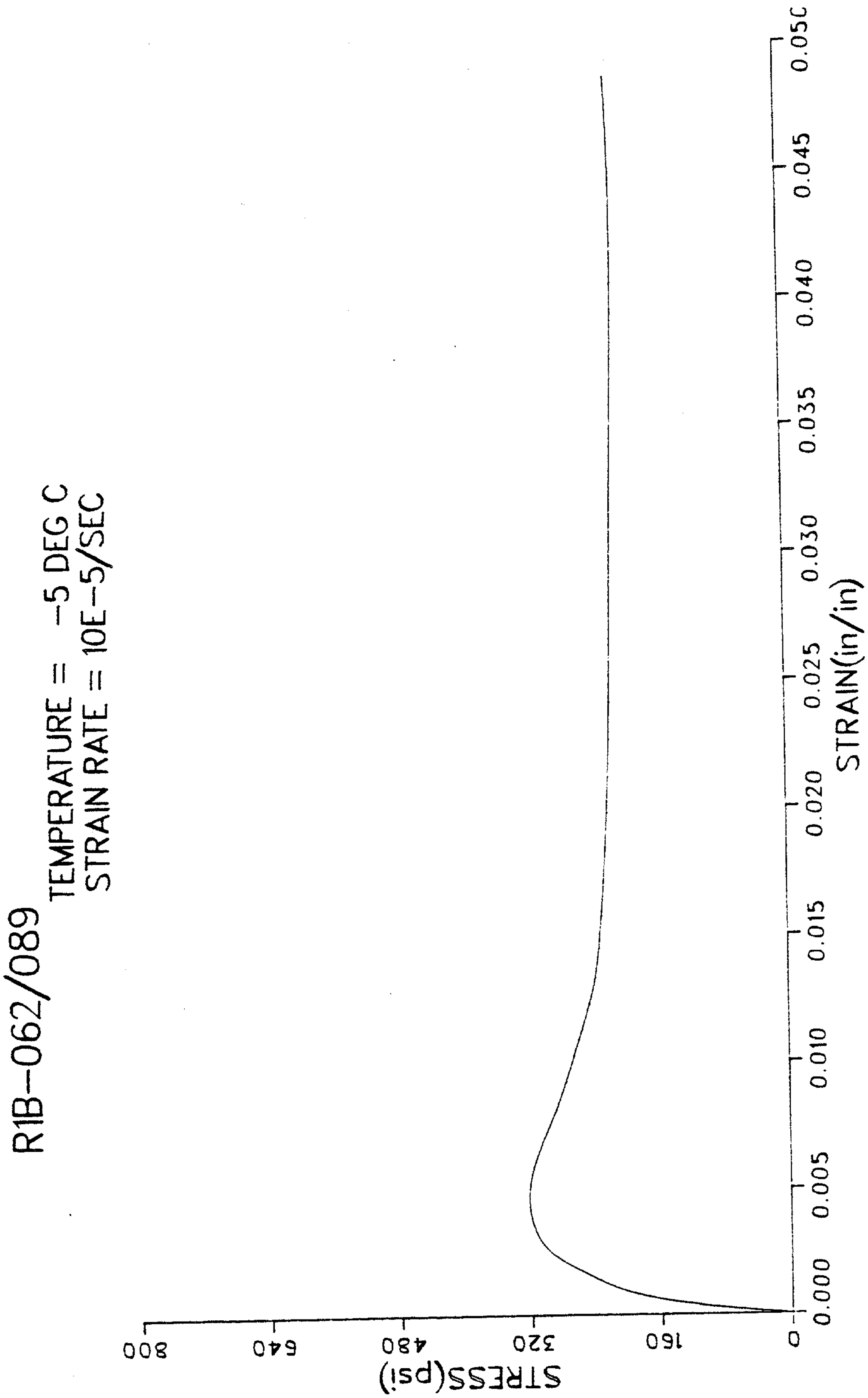
STRESS-STRAIN CURVES

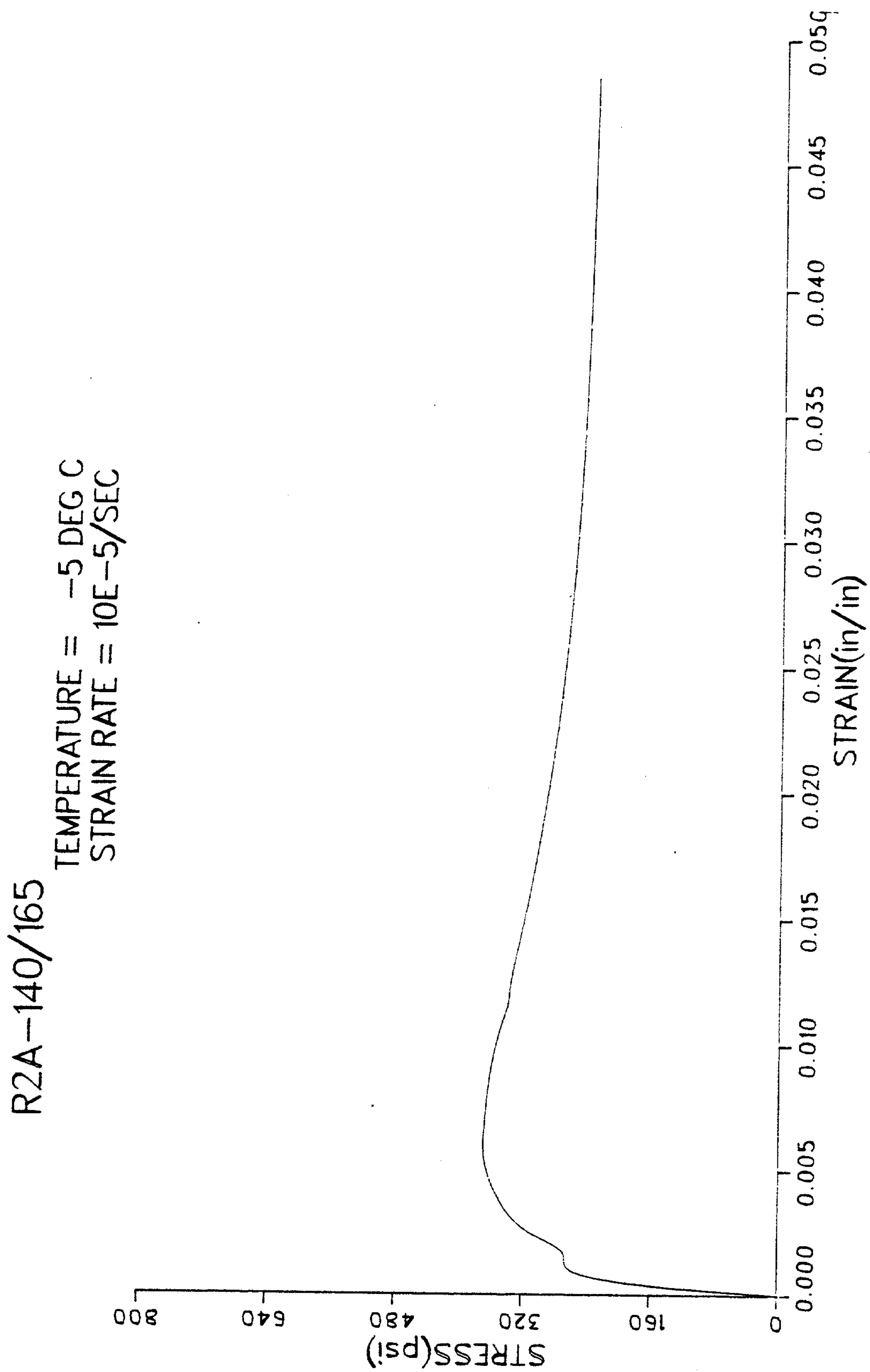
Appendix C

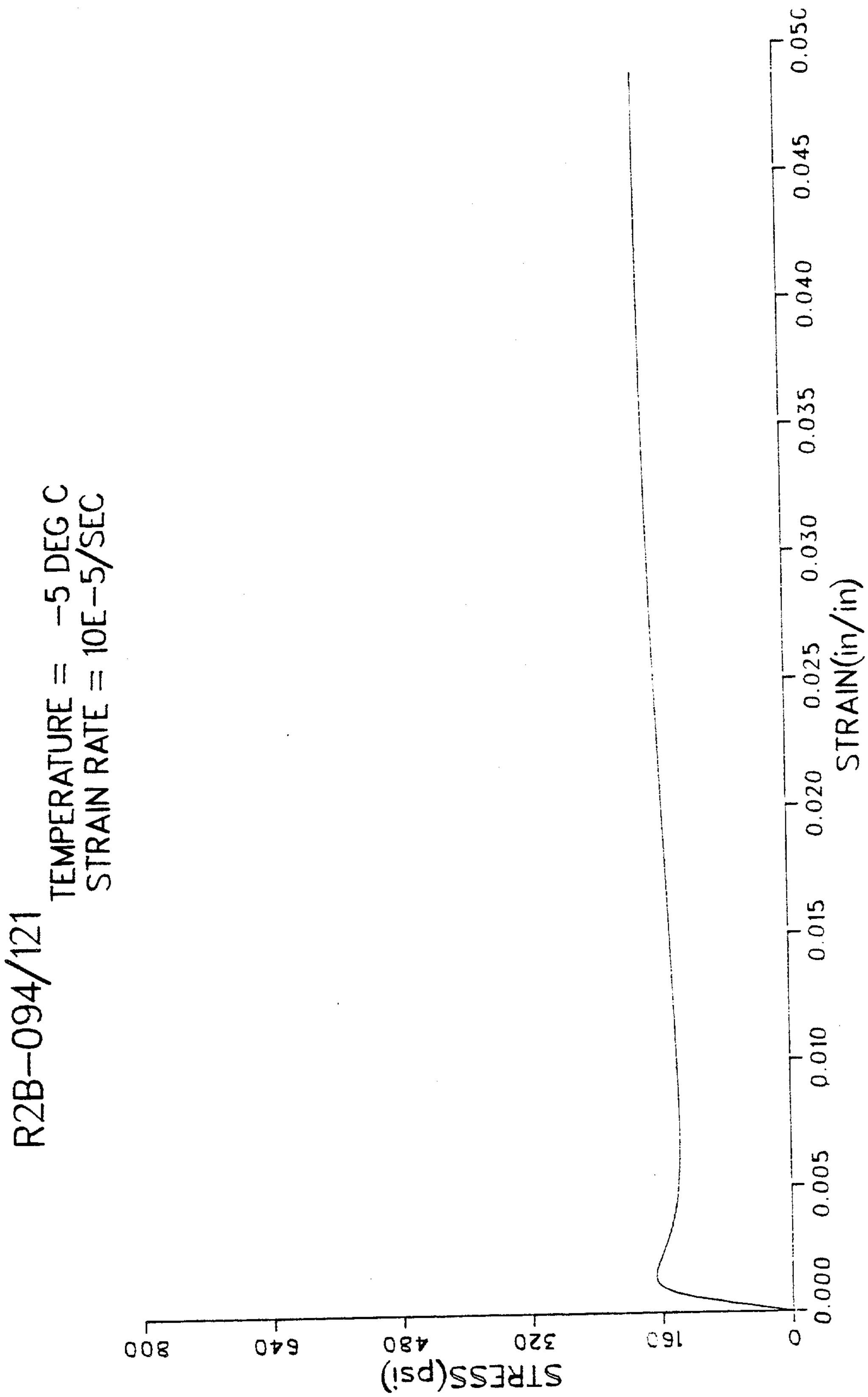
STRESS-STRAIN CURVES

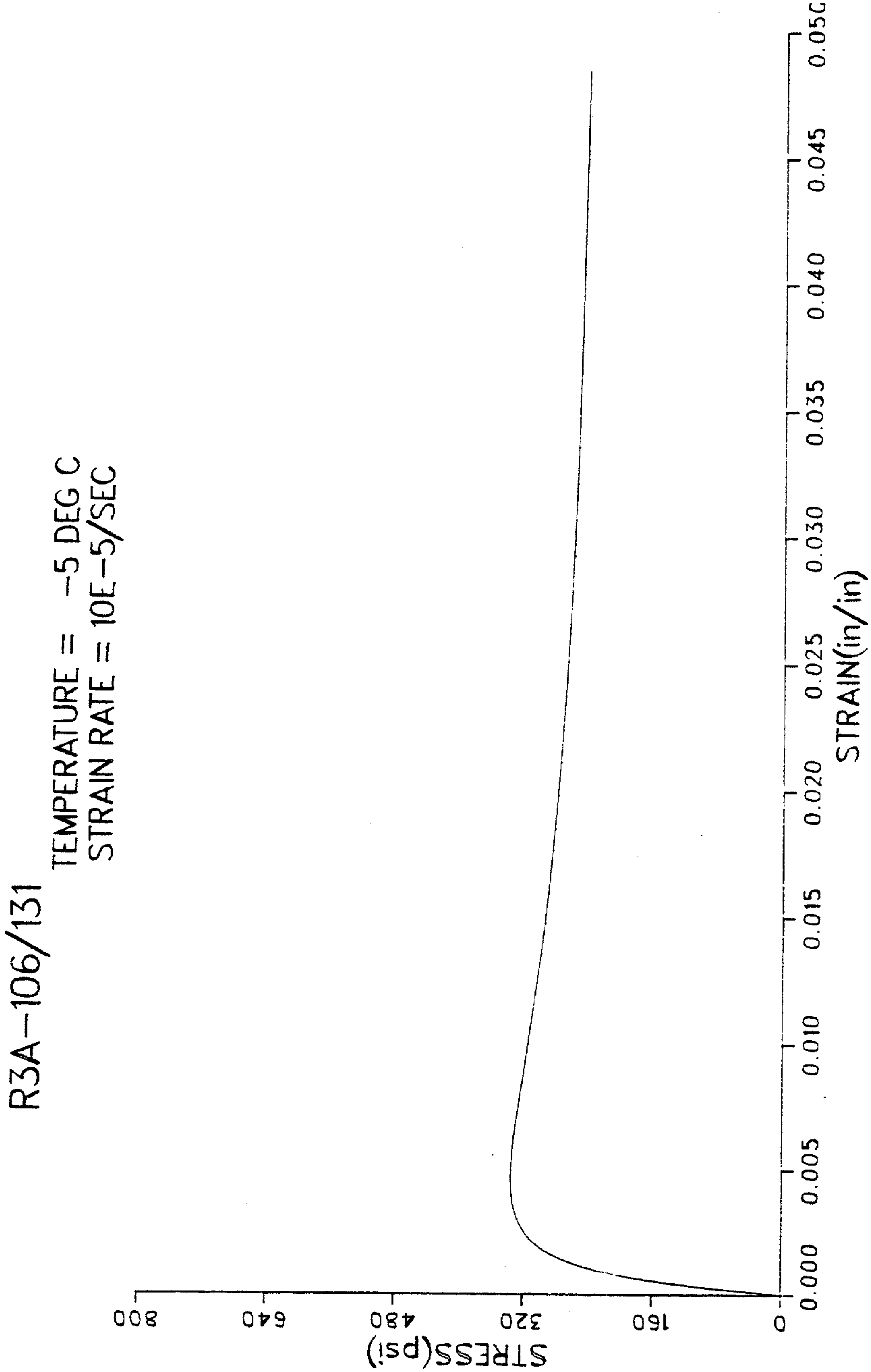
STRAIN RATE = (10E-5)/SEC
TEMPERATURE = -5°C

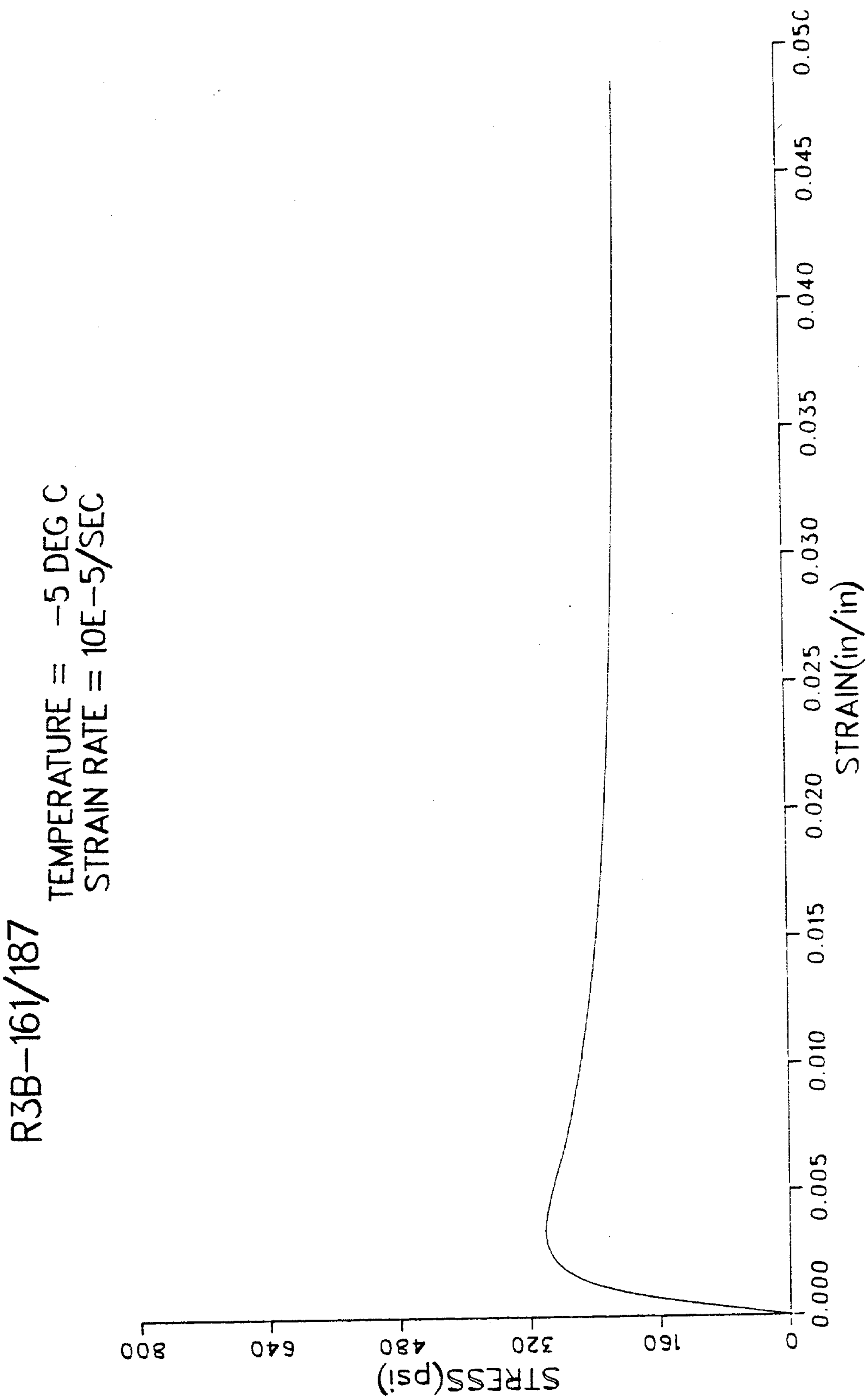

R1A-062/089
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

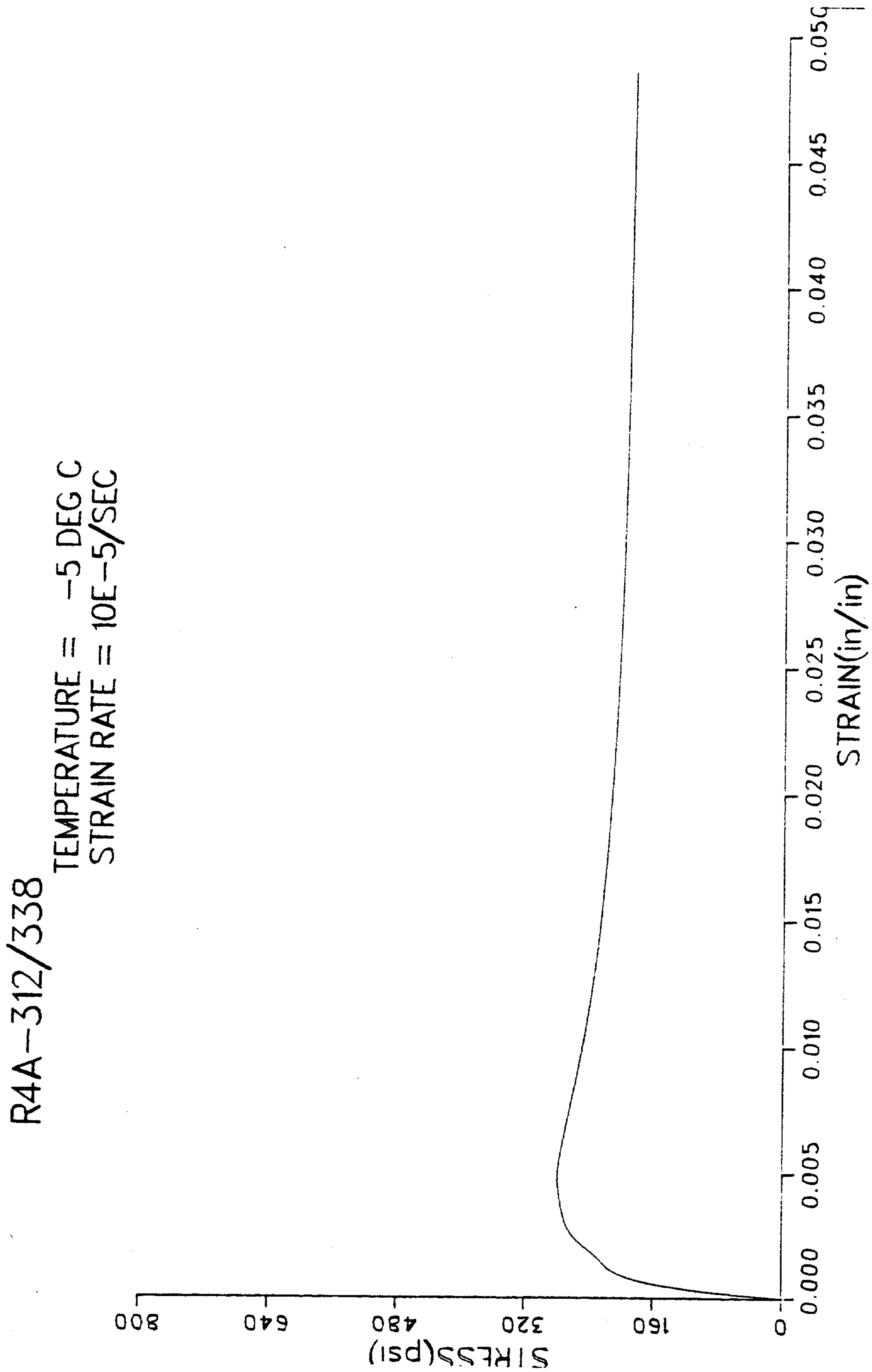

R1B-062/089
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

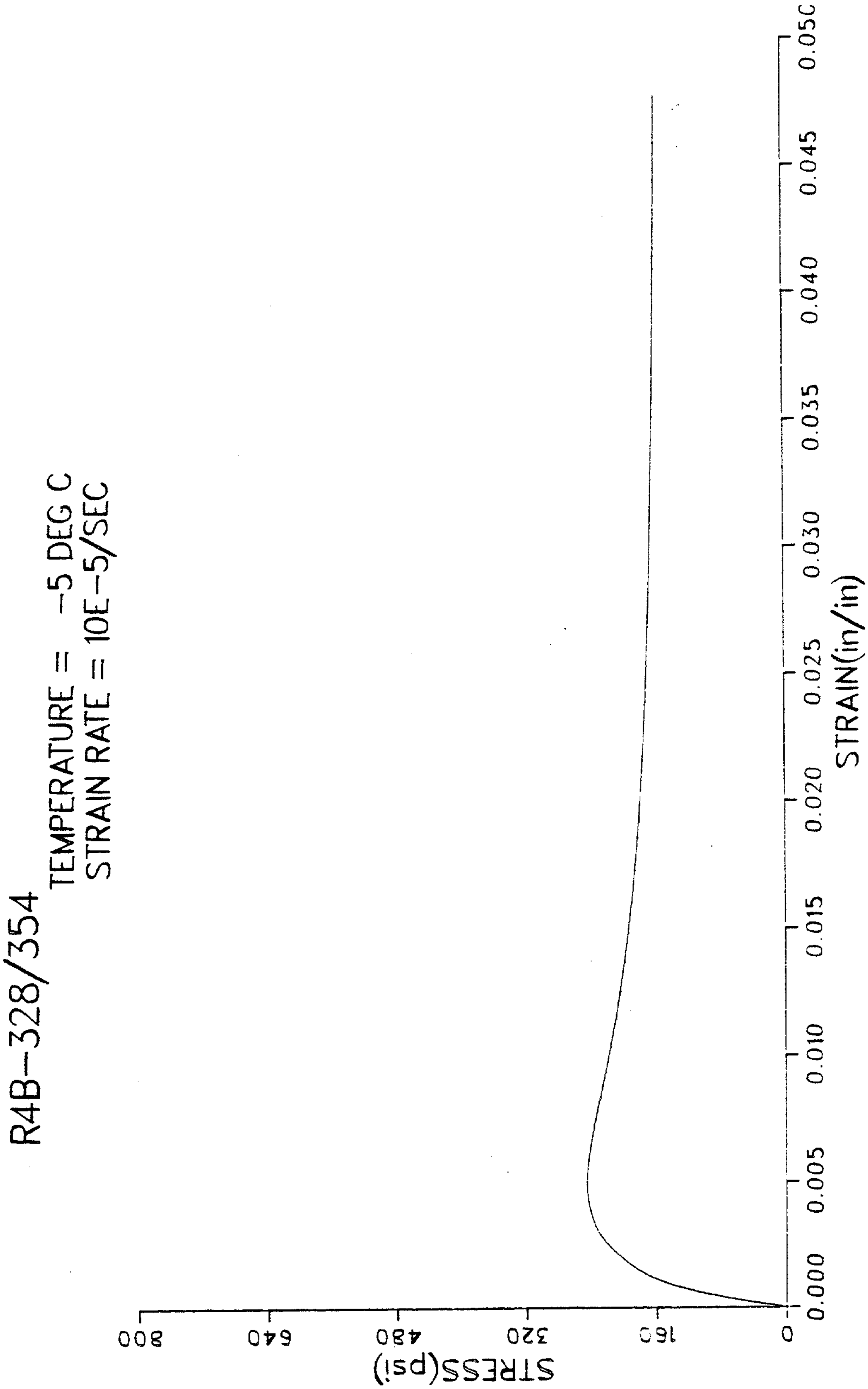

R2A-140/165
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

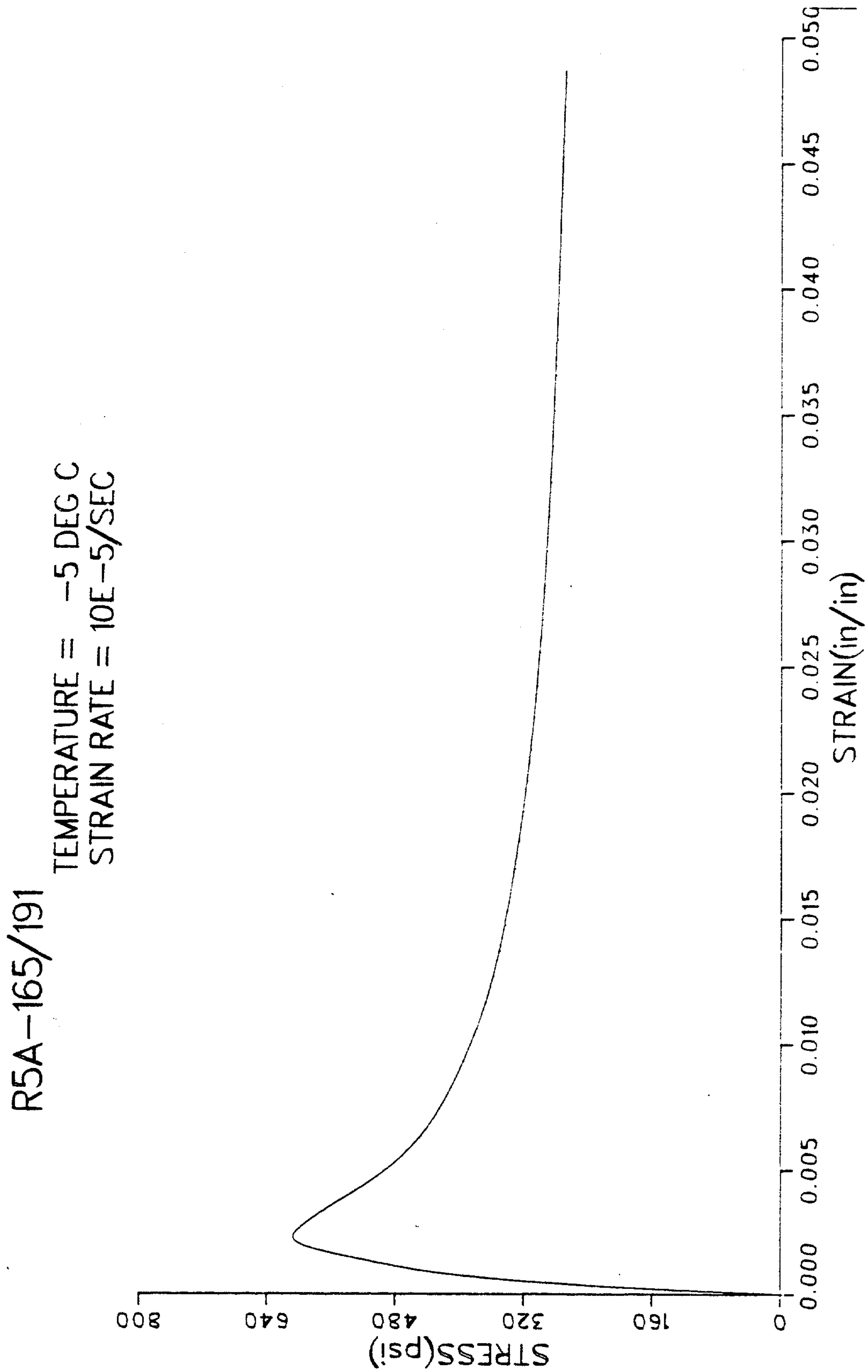

R2B-094/121
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

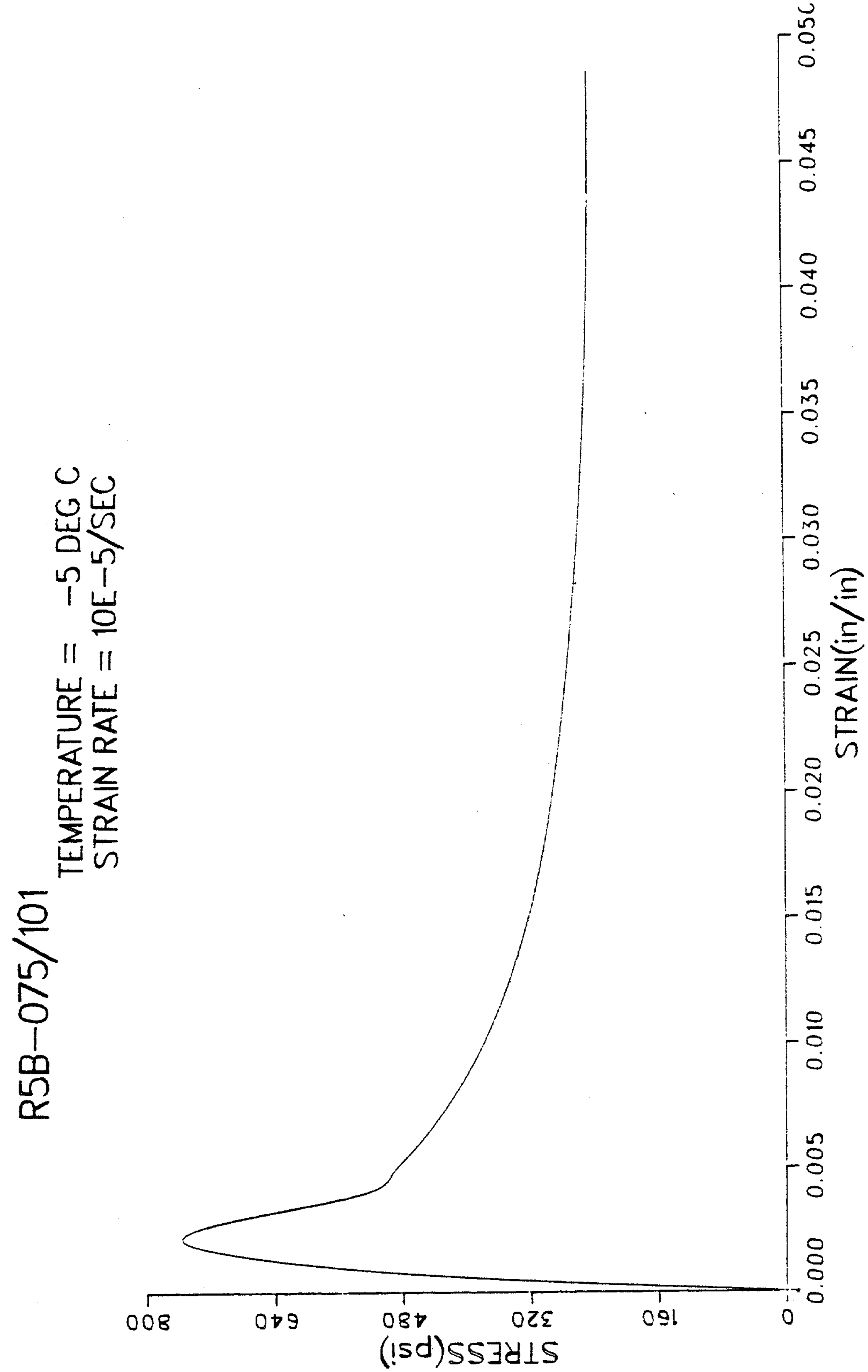

R3A-106/131
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

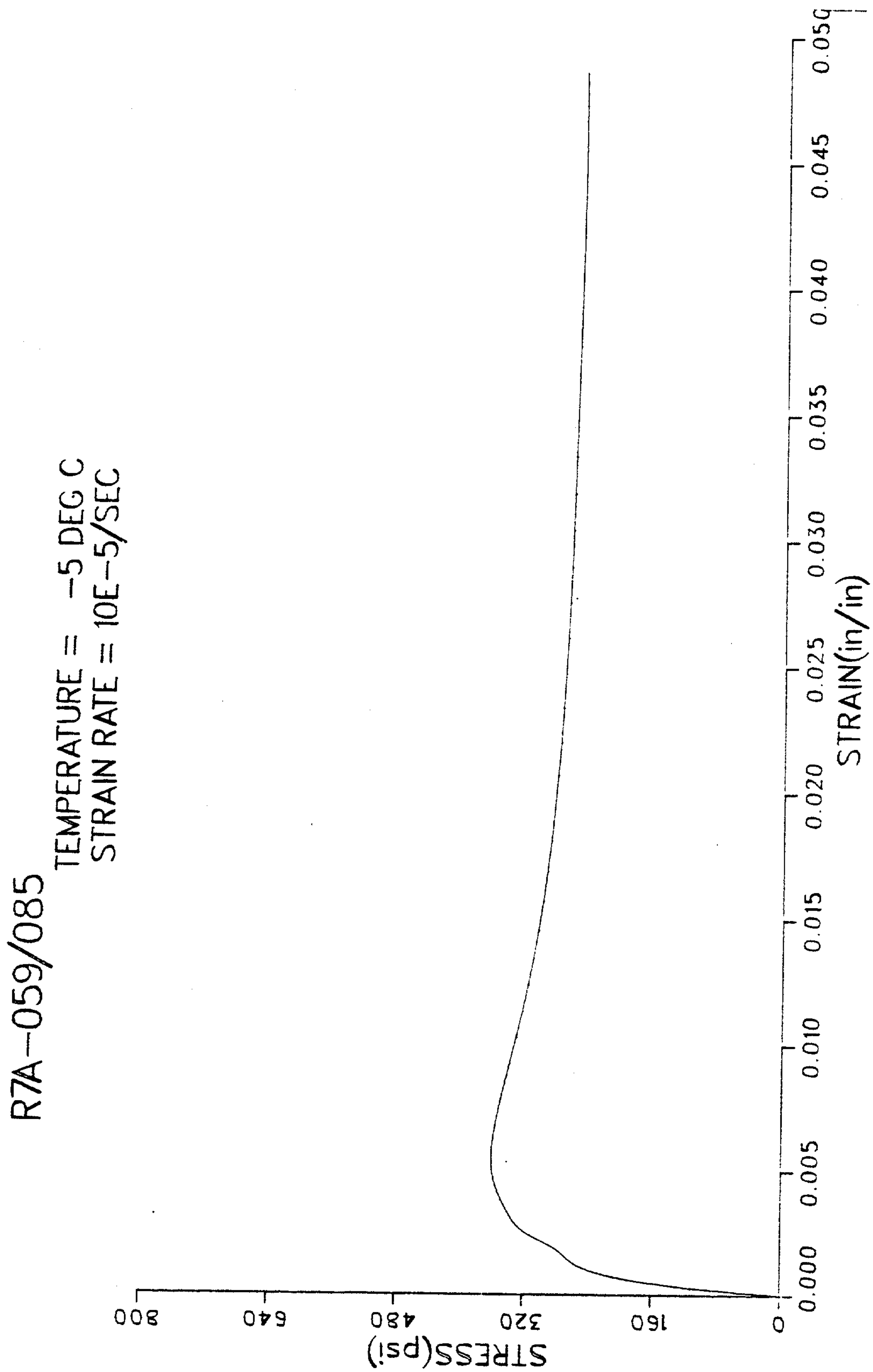

R3B-161/187
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

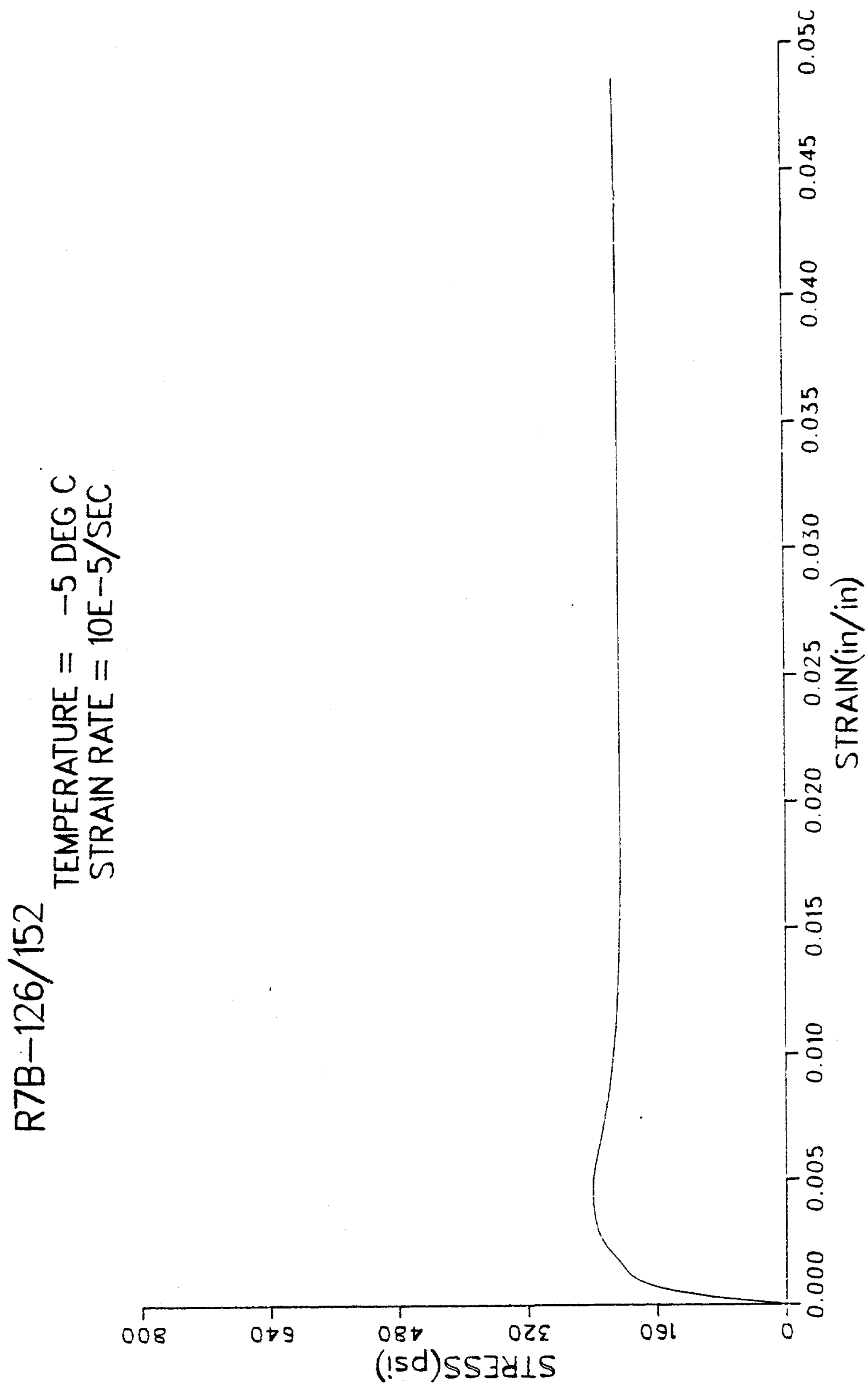

R4A–312/338
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–5/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
160
320
480
640
800

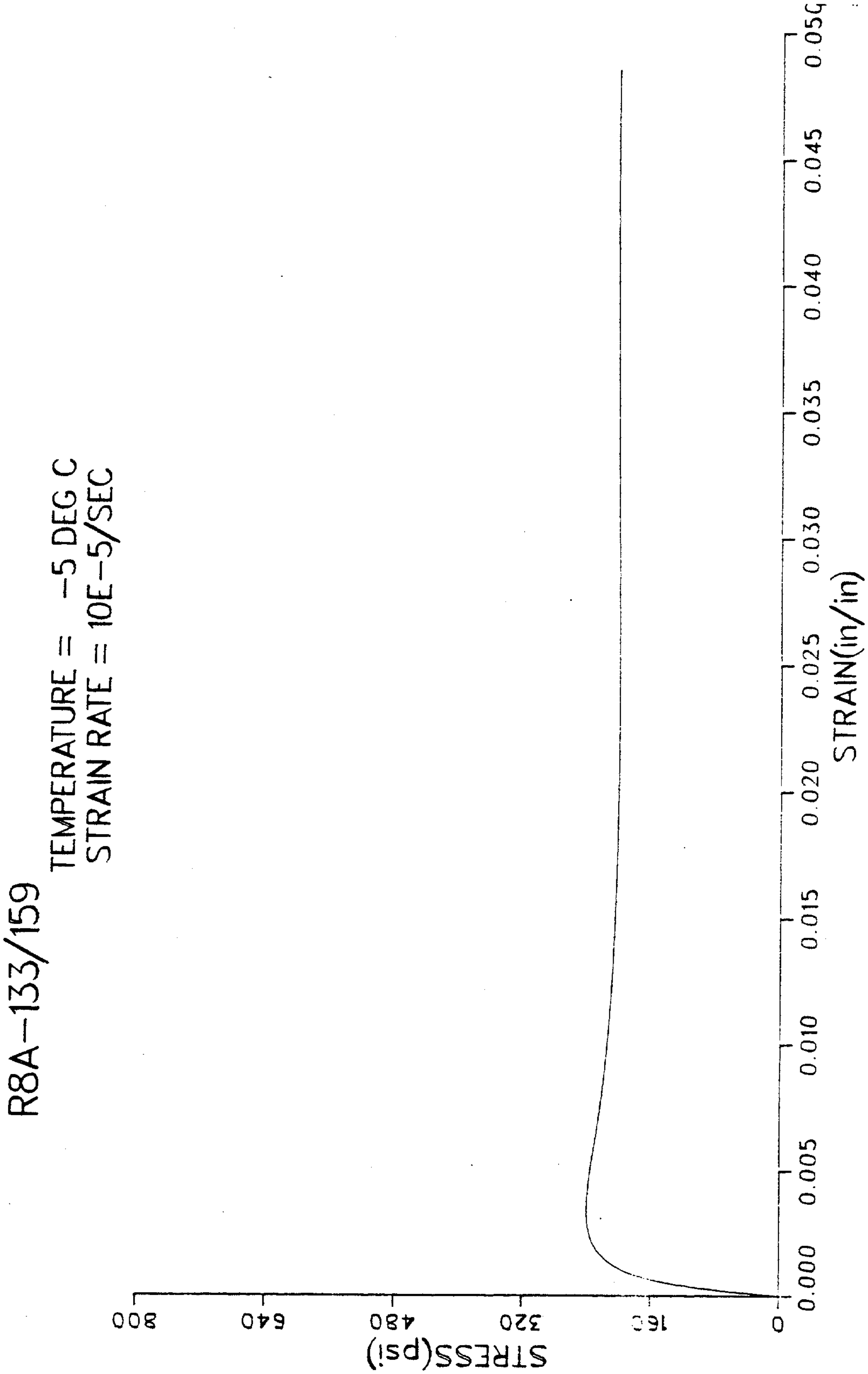

R4B-328/354
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

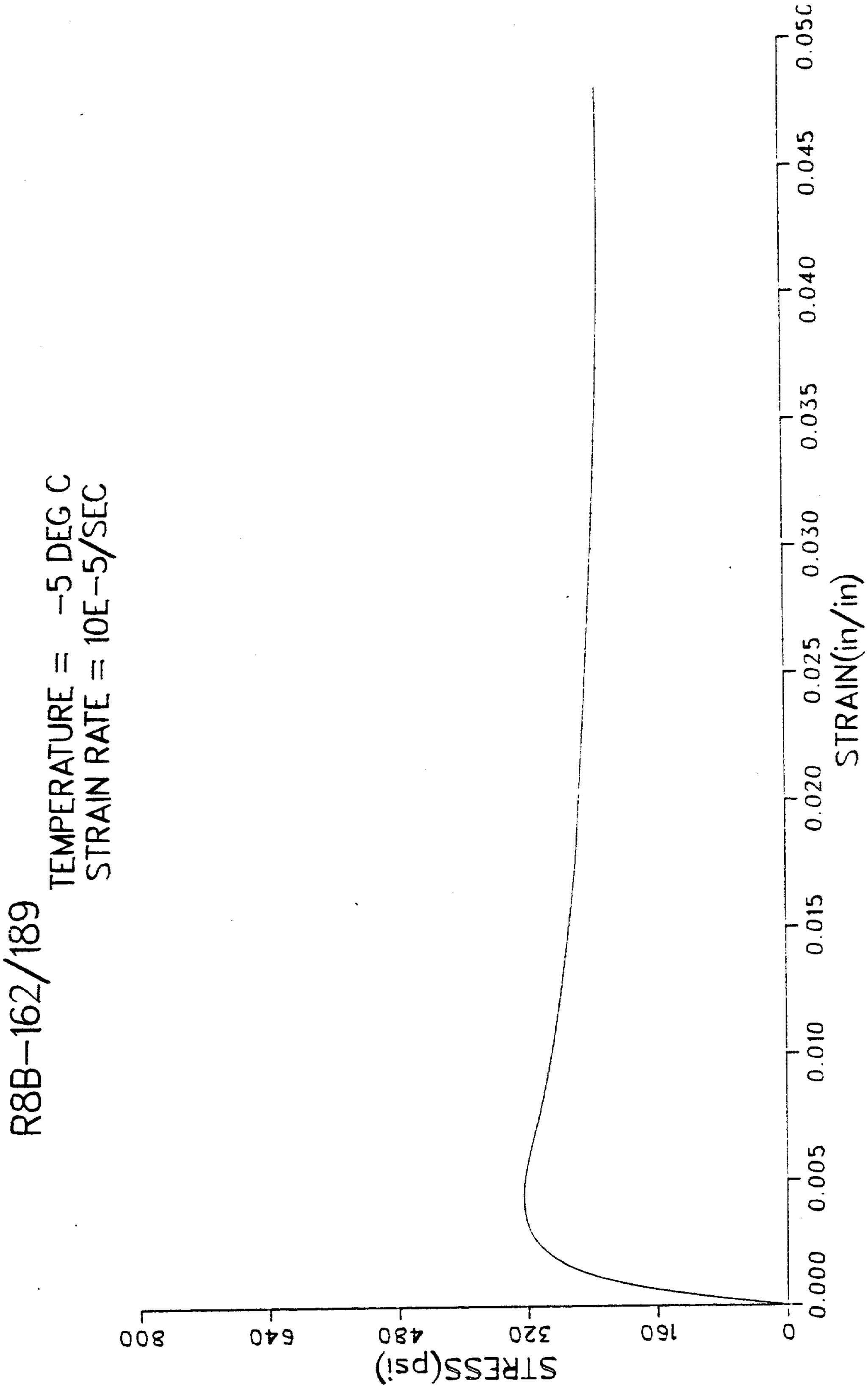

R5A-165/191
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

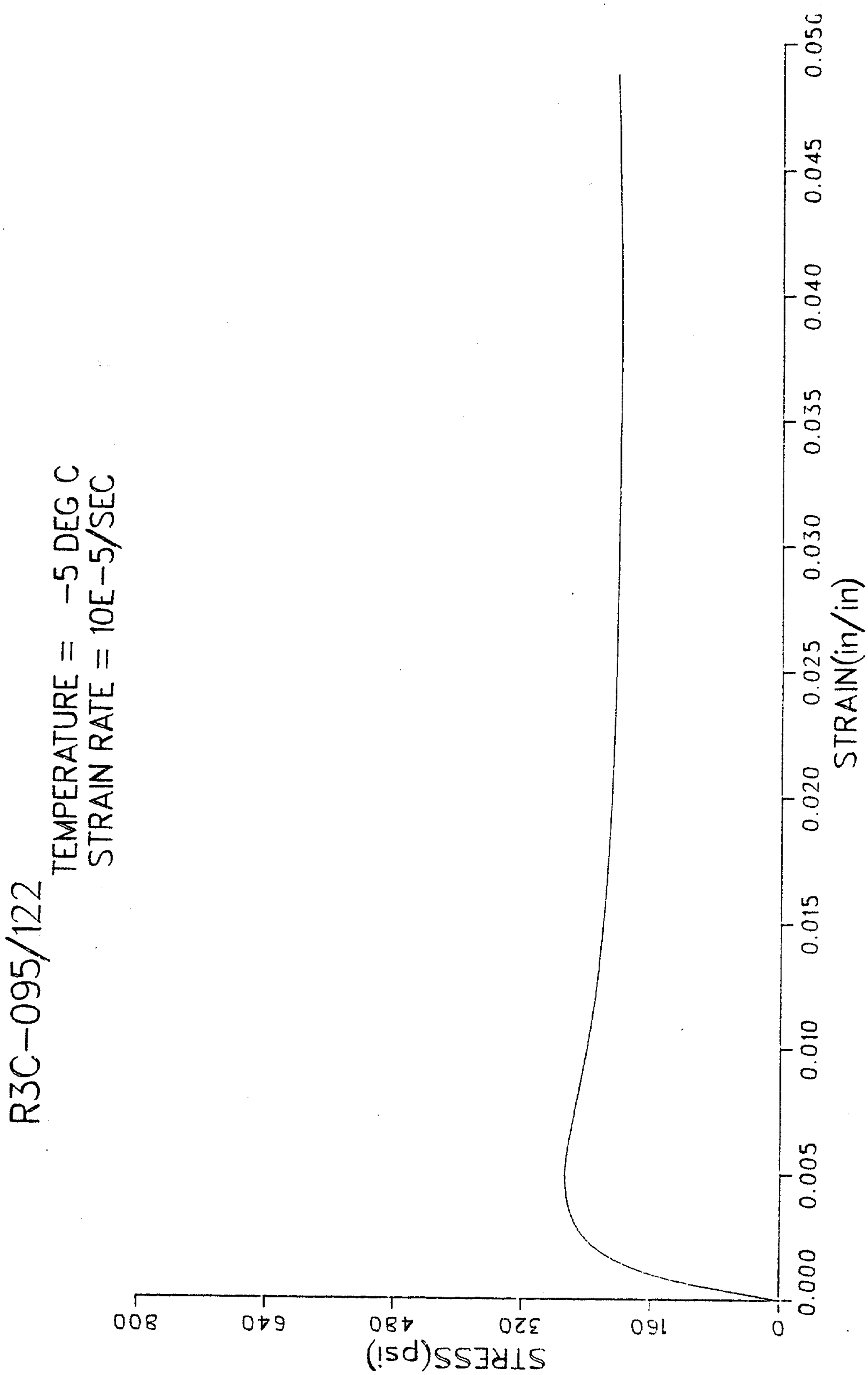

R5B-075/101
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
160
320
480
640
800

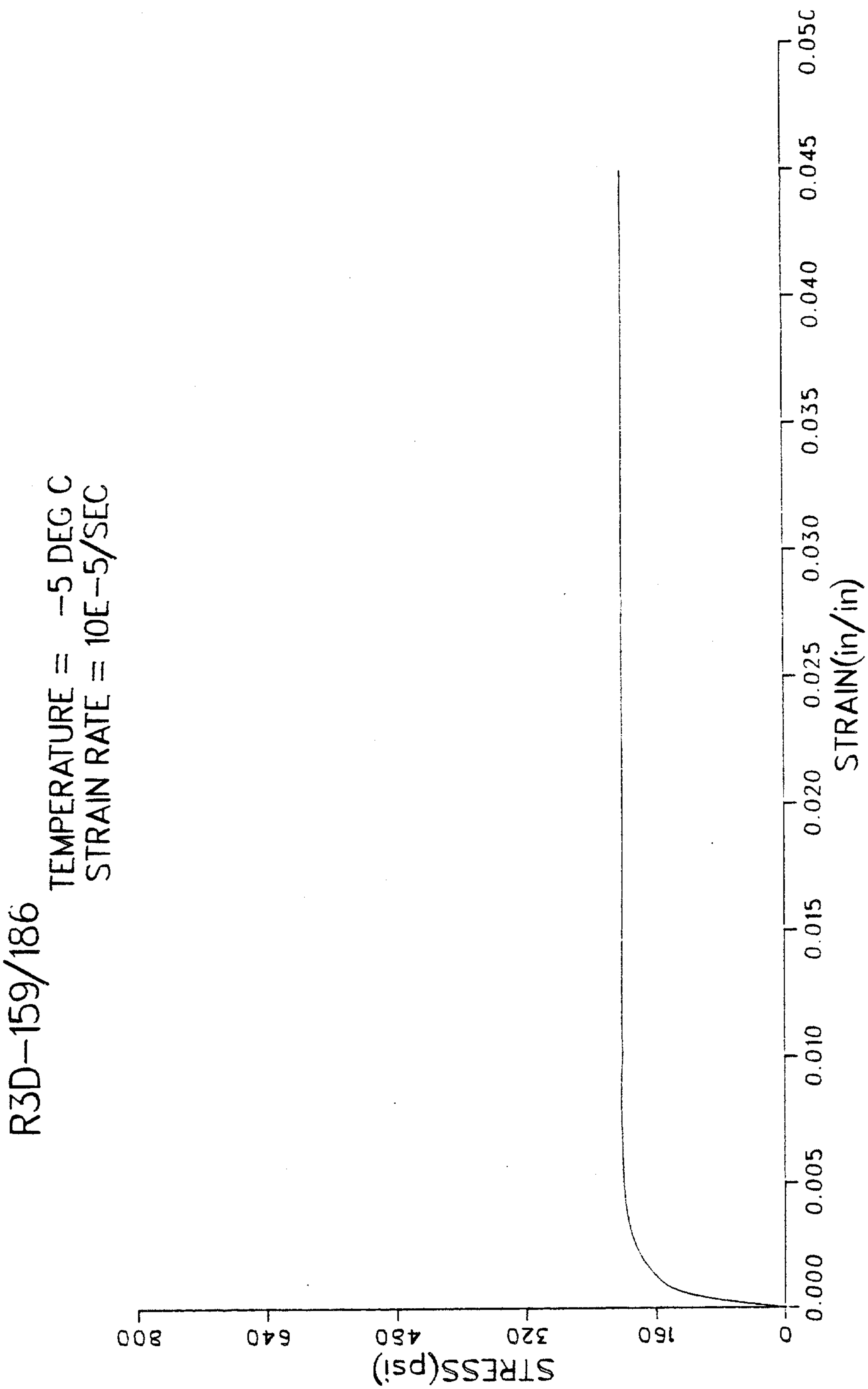

R7A–059/085
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

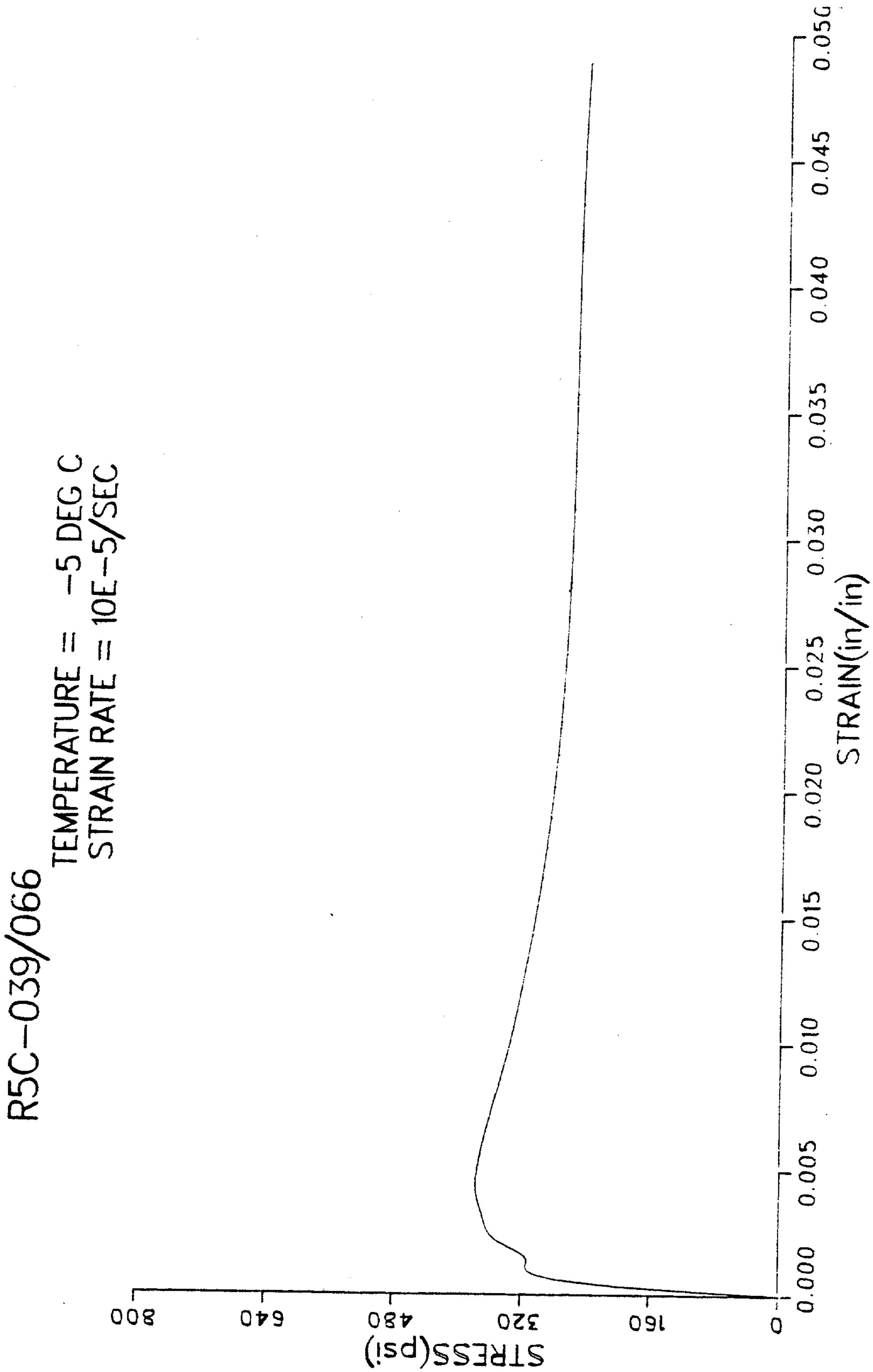

R7B-126/152
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

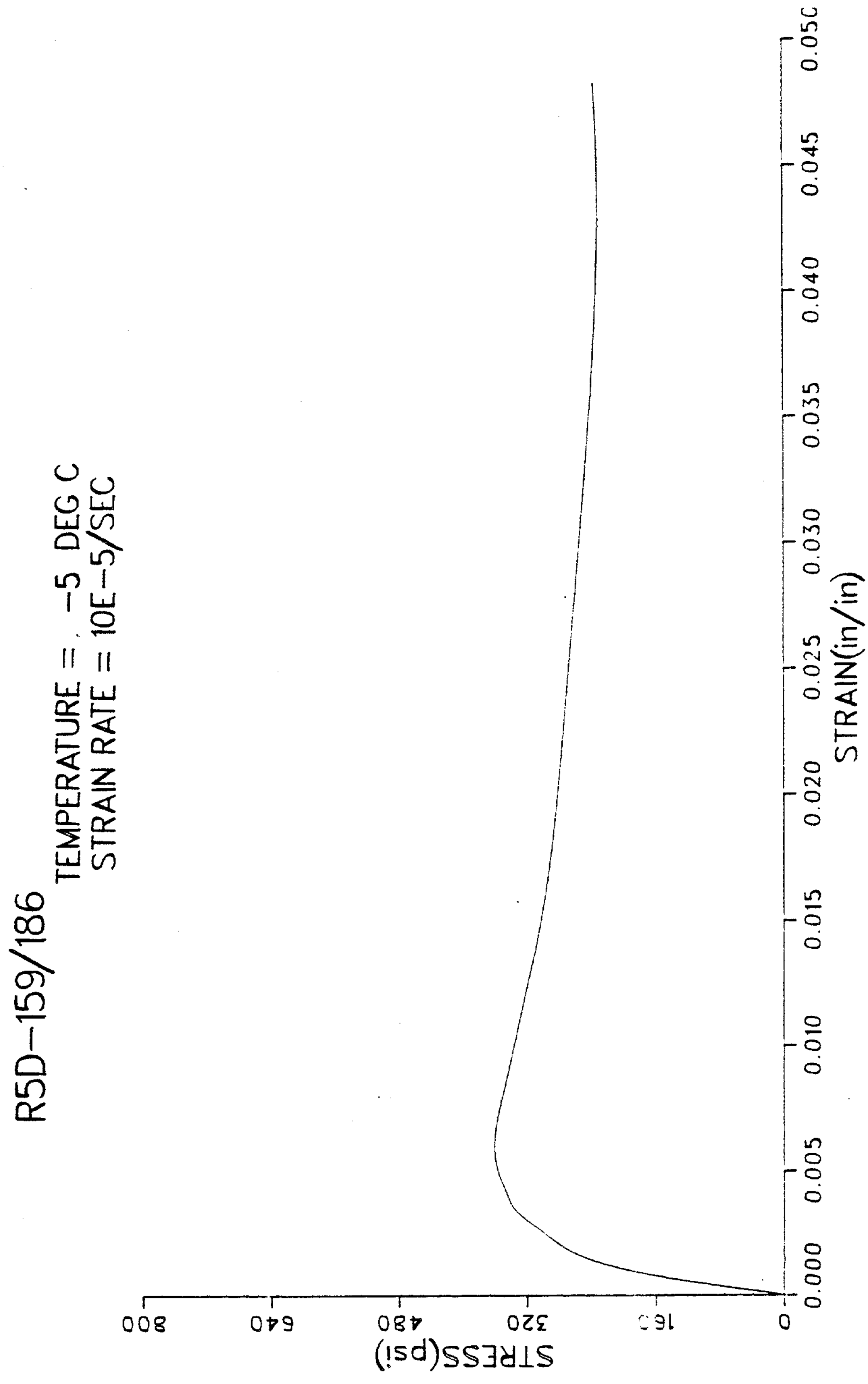

R8A–133/159
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

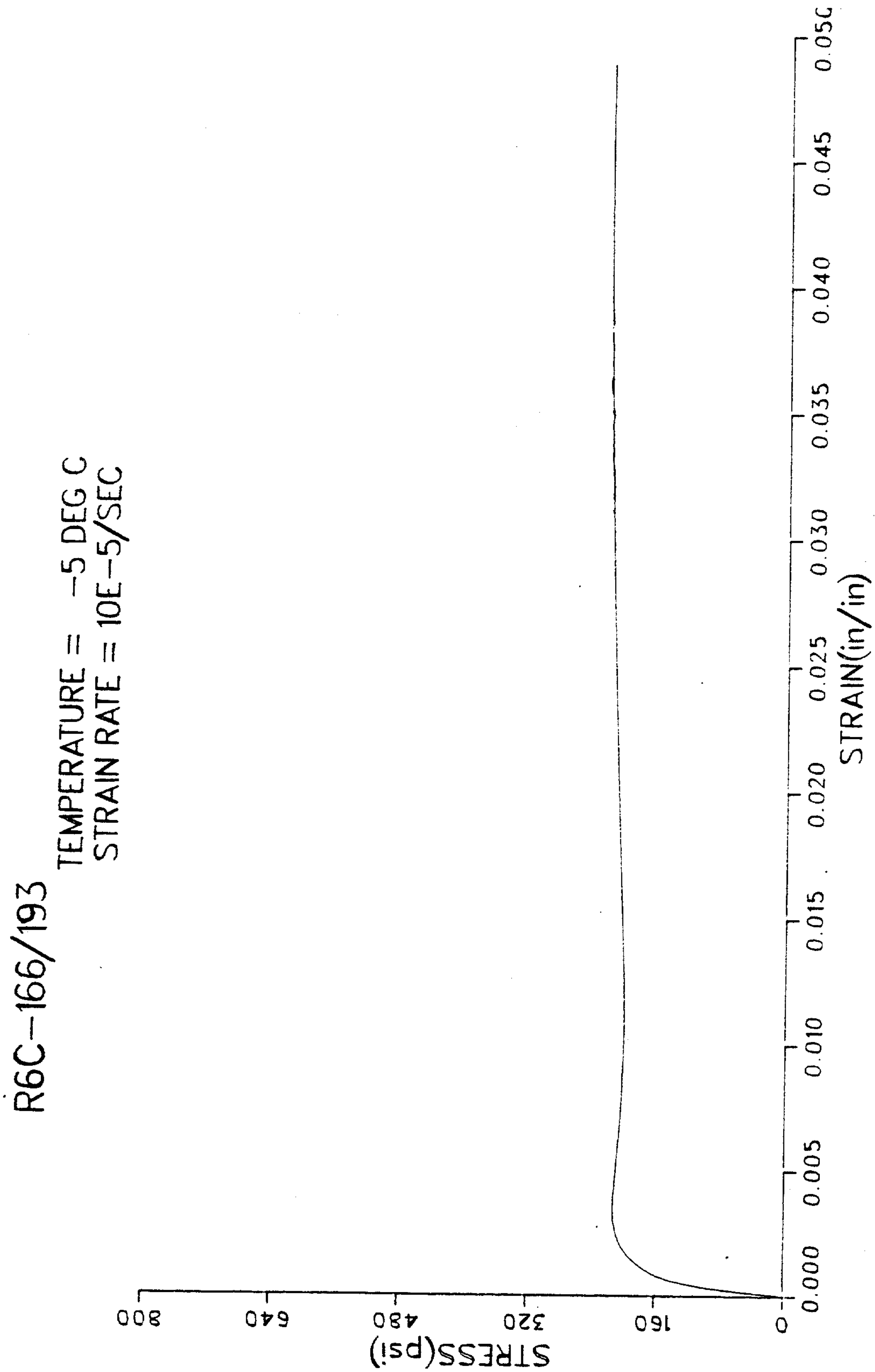

R8B-162/189
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

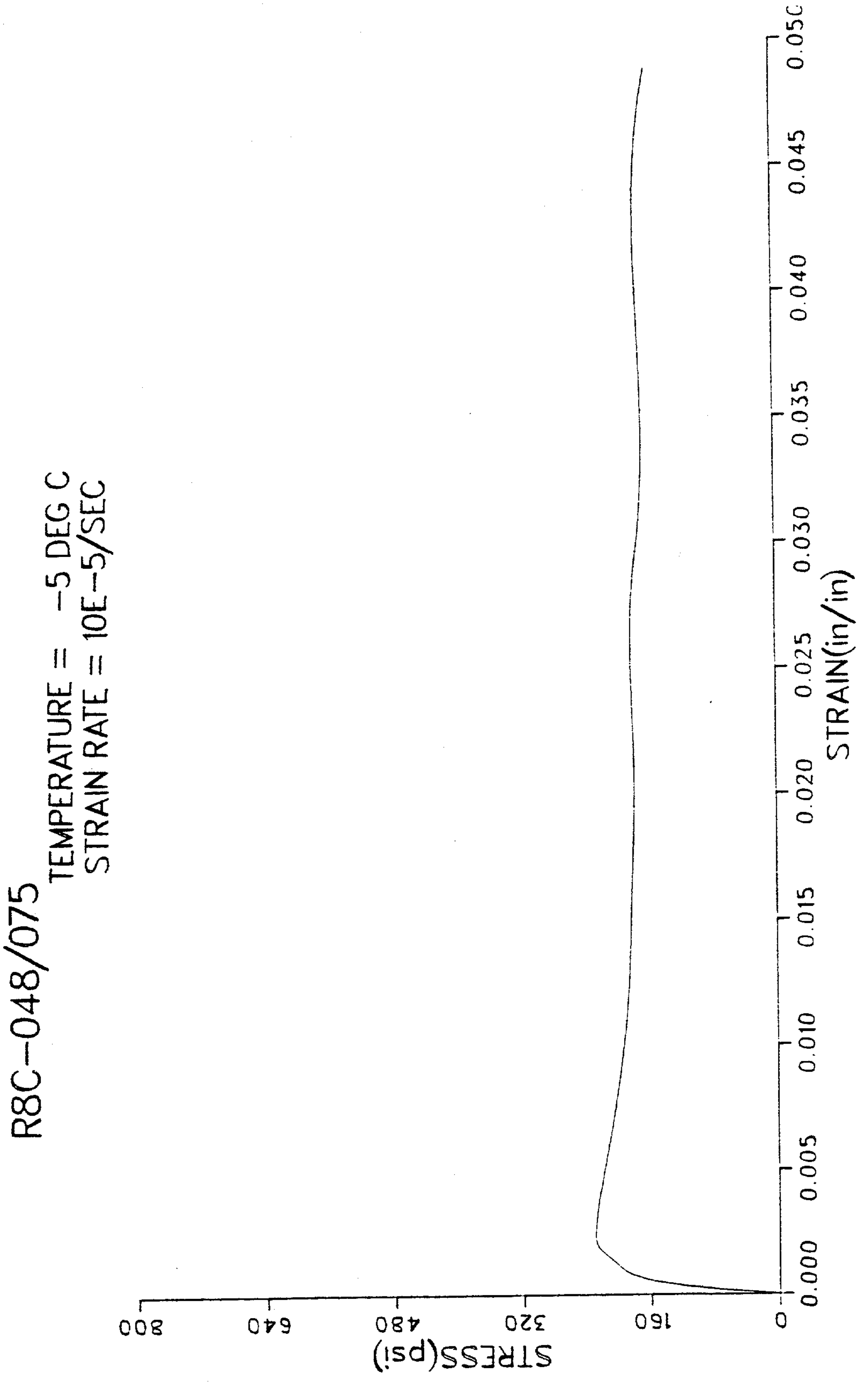

R3C-095/122
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

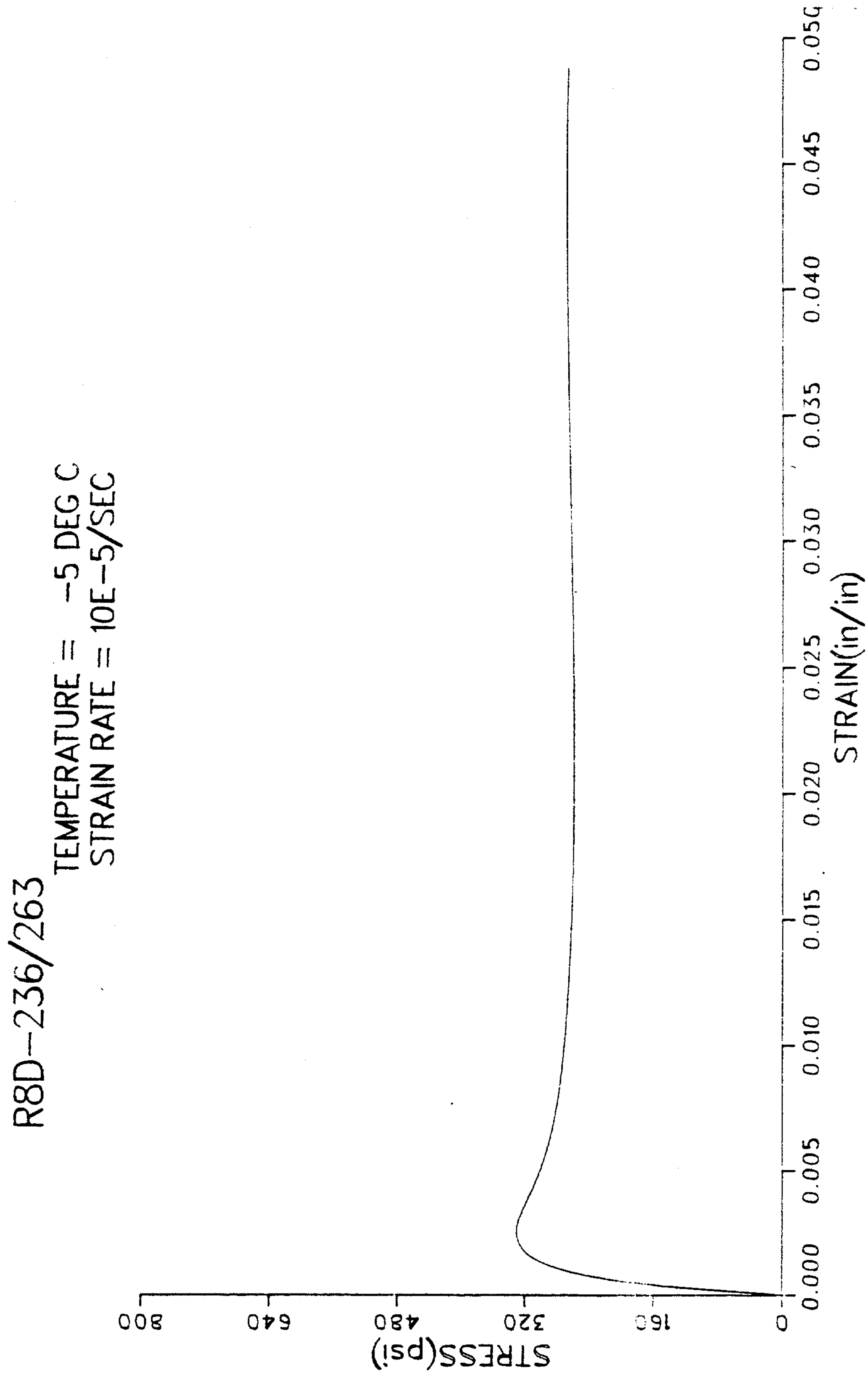

R3D-159/186
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
160
320
480
640
800

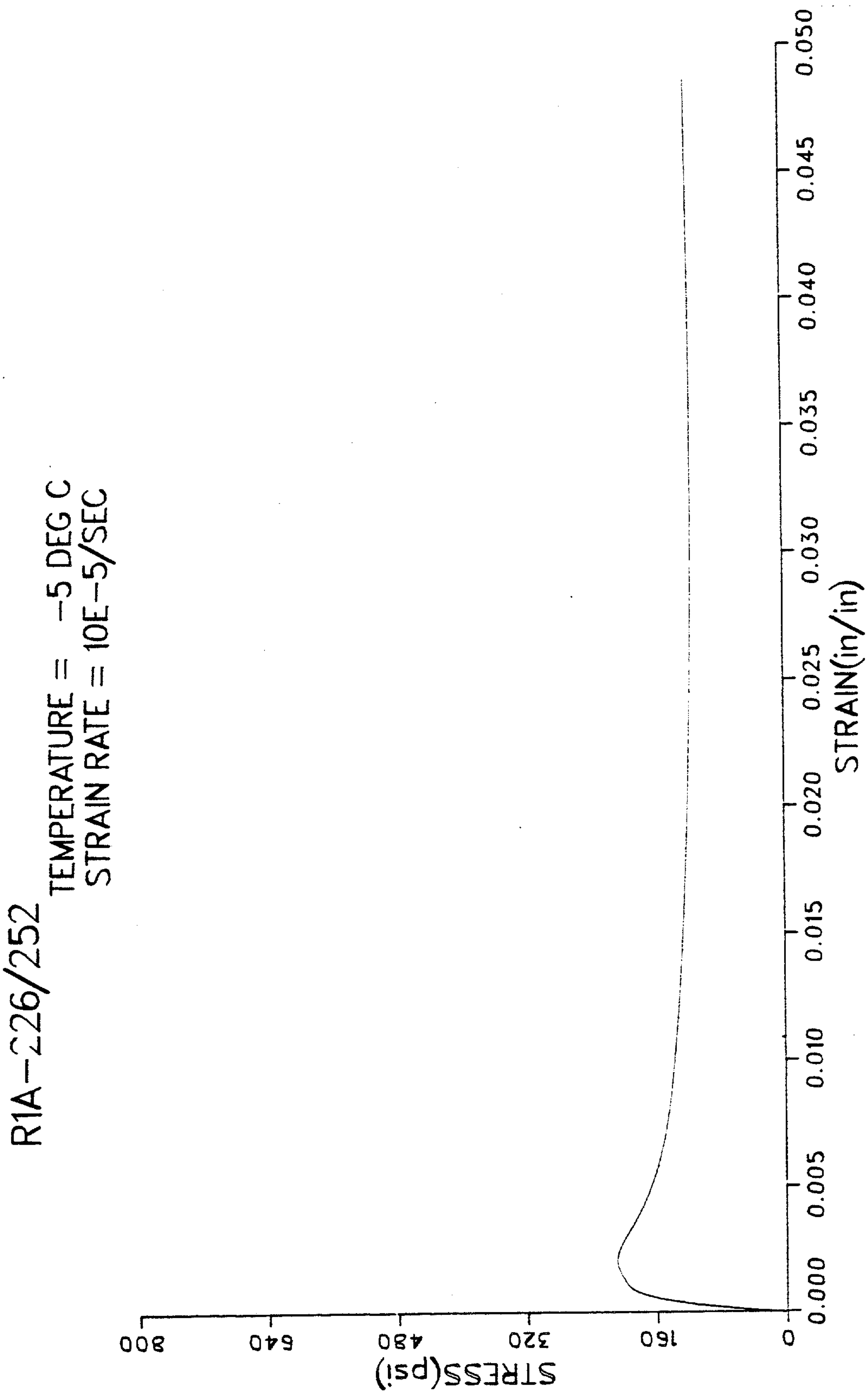

R5C-039/066
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

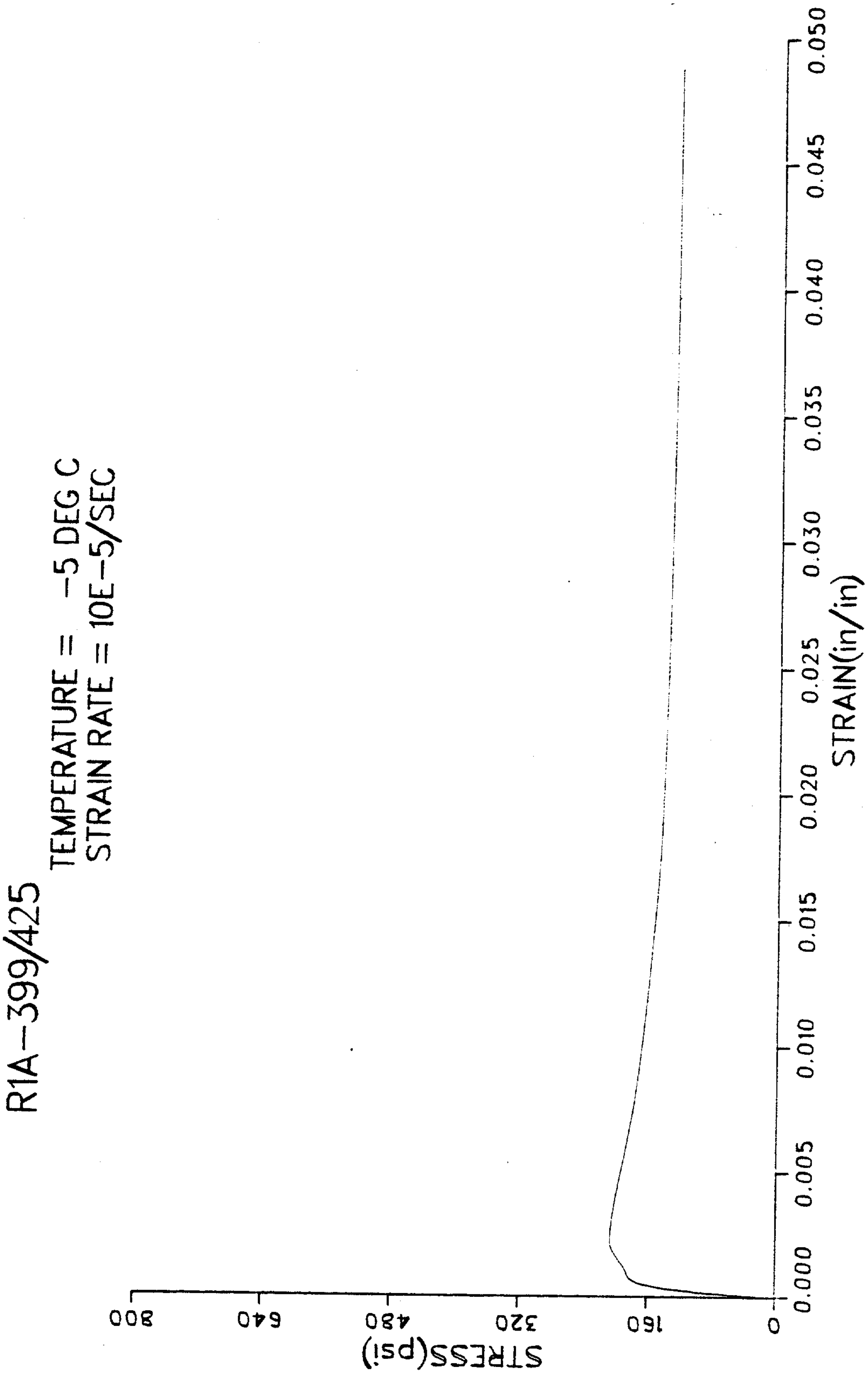

R5D-159/186
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

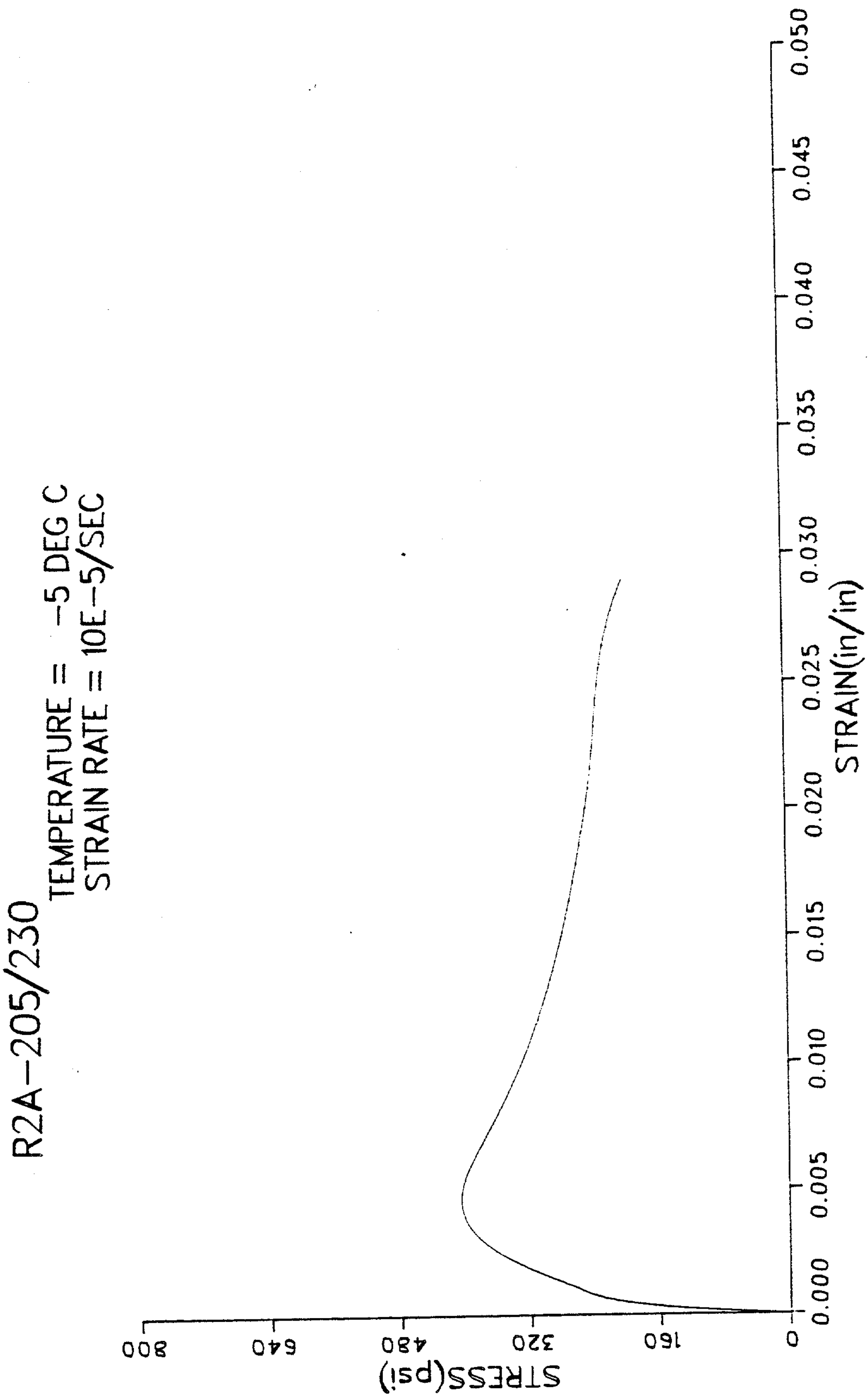

R6C-166/193
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

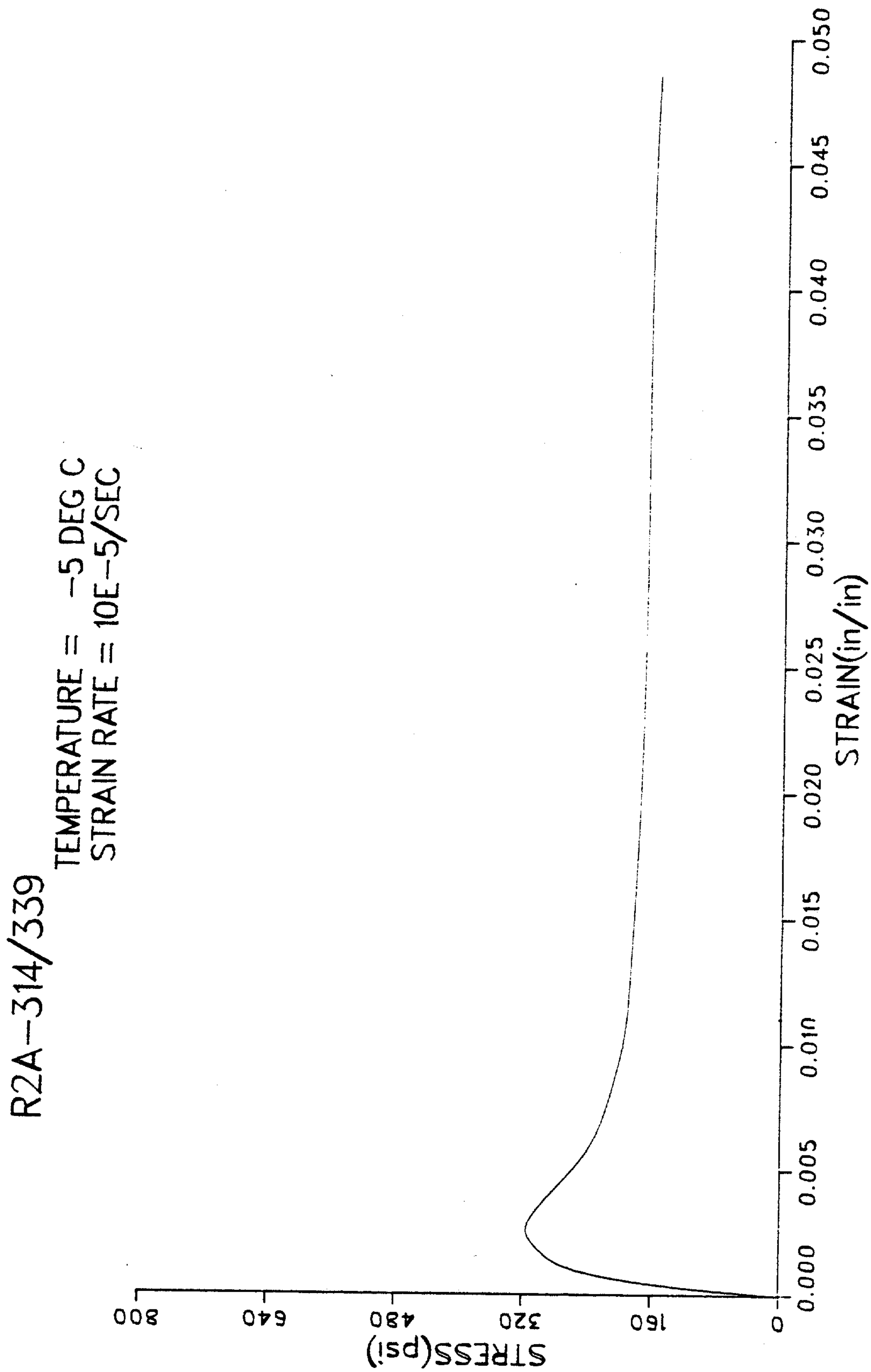

R8C–048/075
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

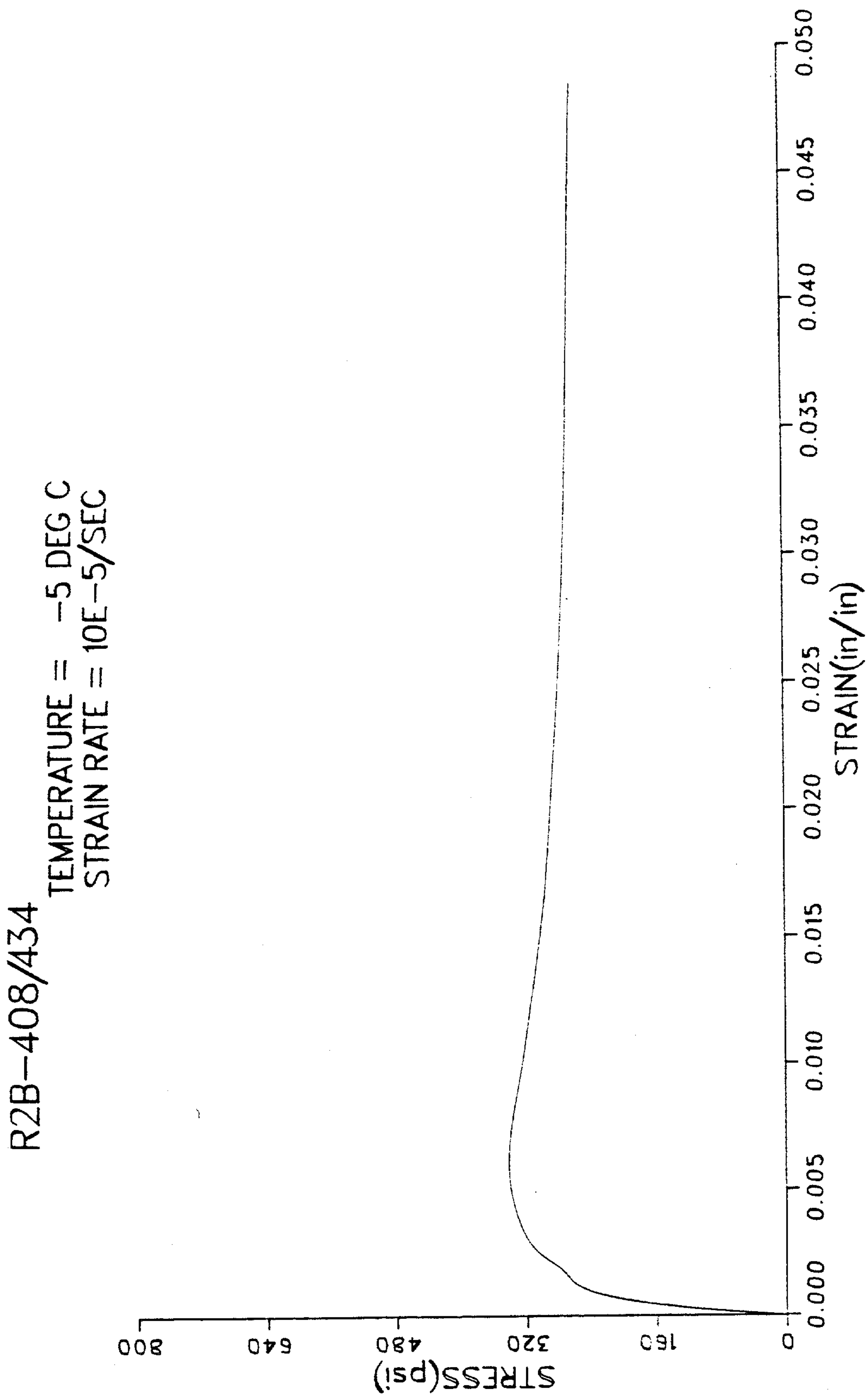

R8D-236/263
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
STRAIN(in/in)
0
160
320
480
640
800
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

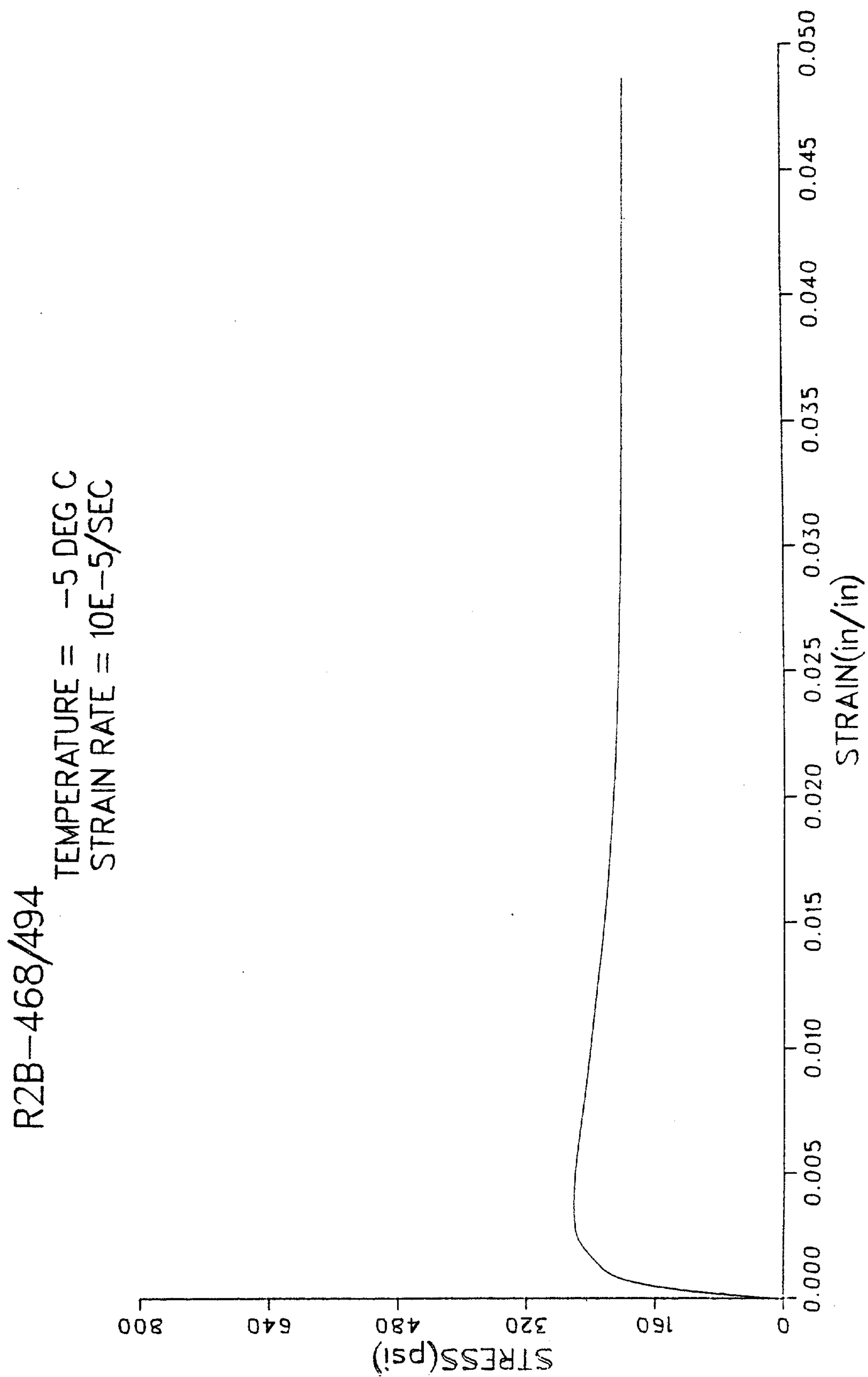

R1A-226/252
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

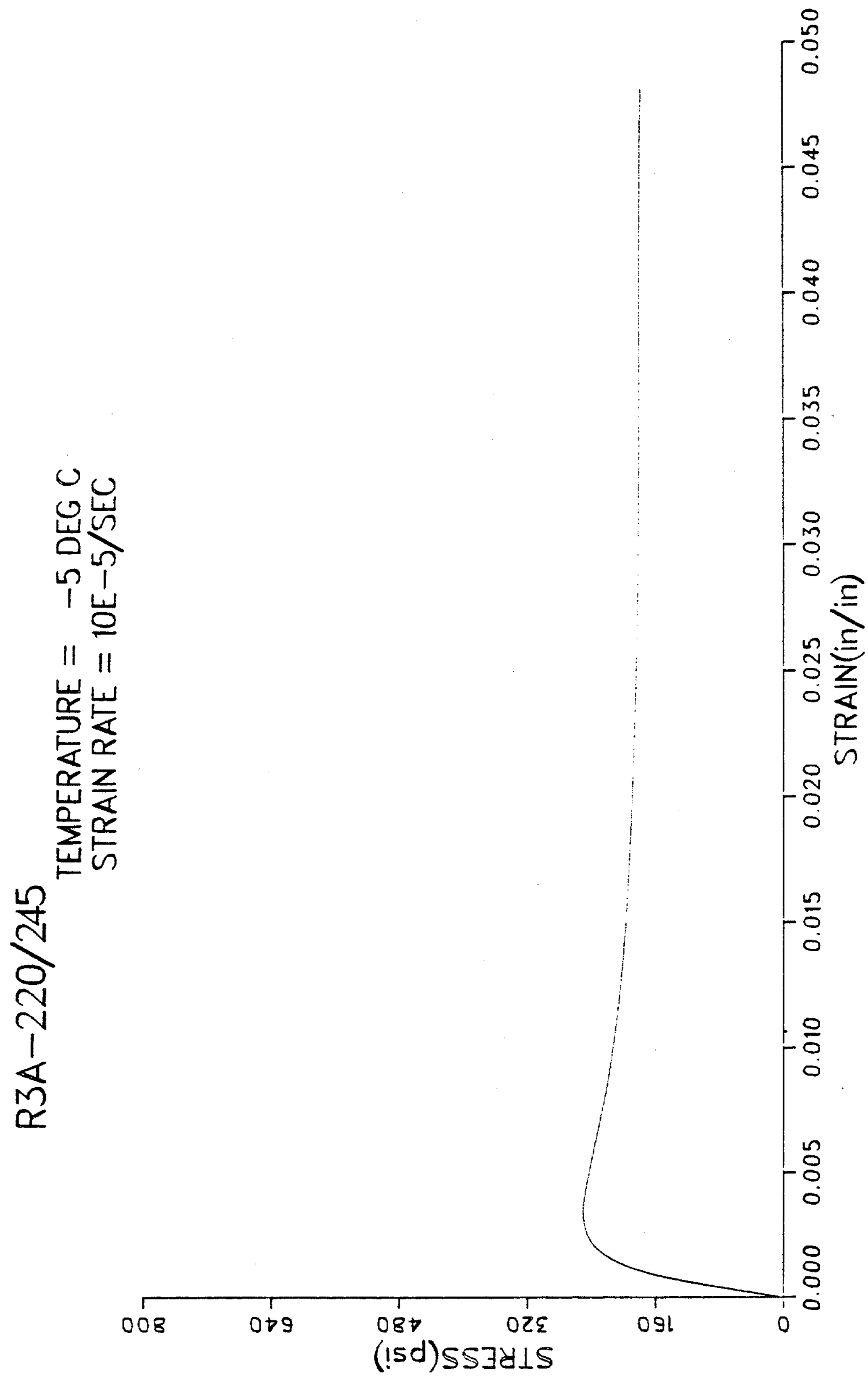

R1A–399/425
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

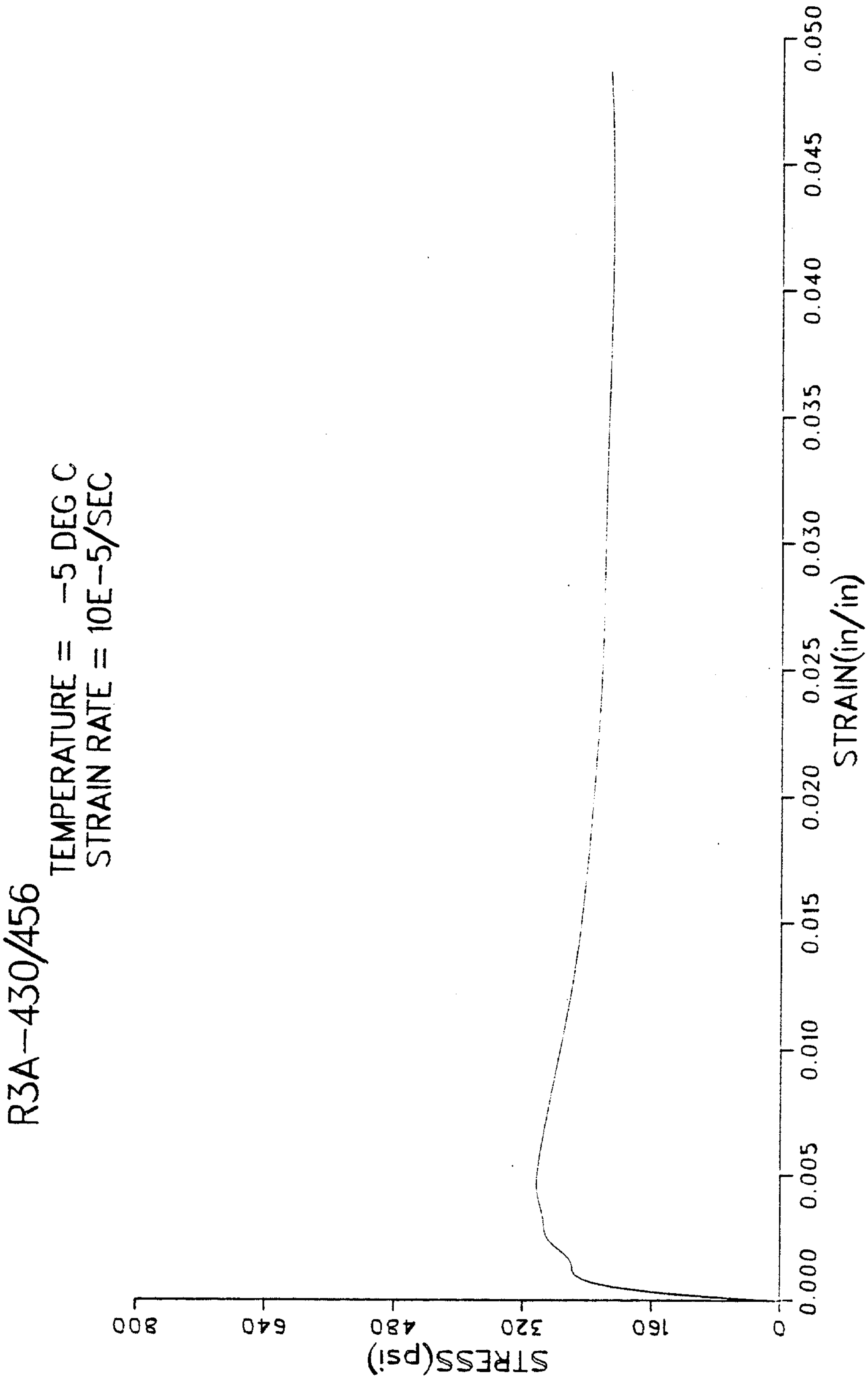

R2A-205/230
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

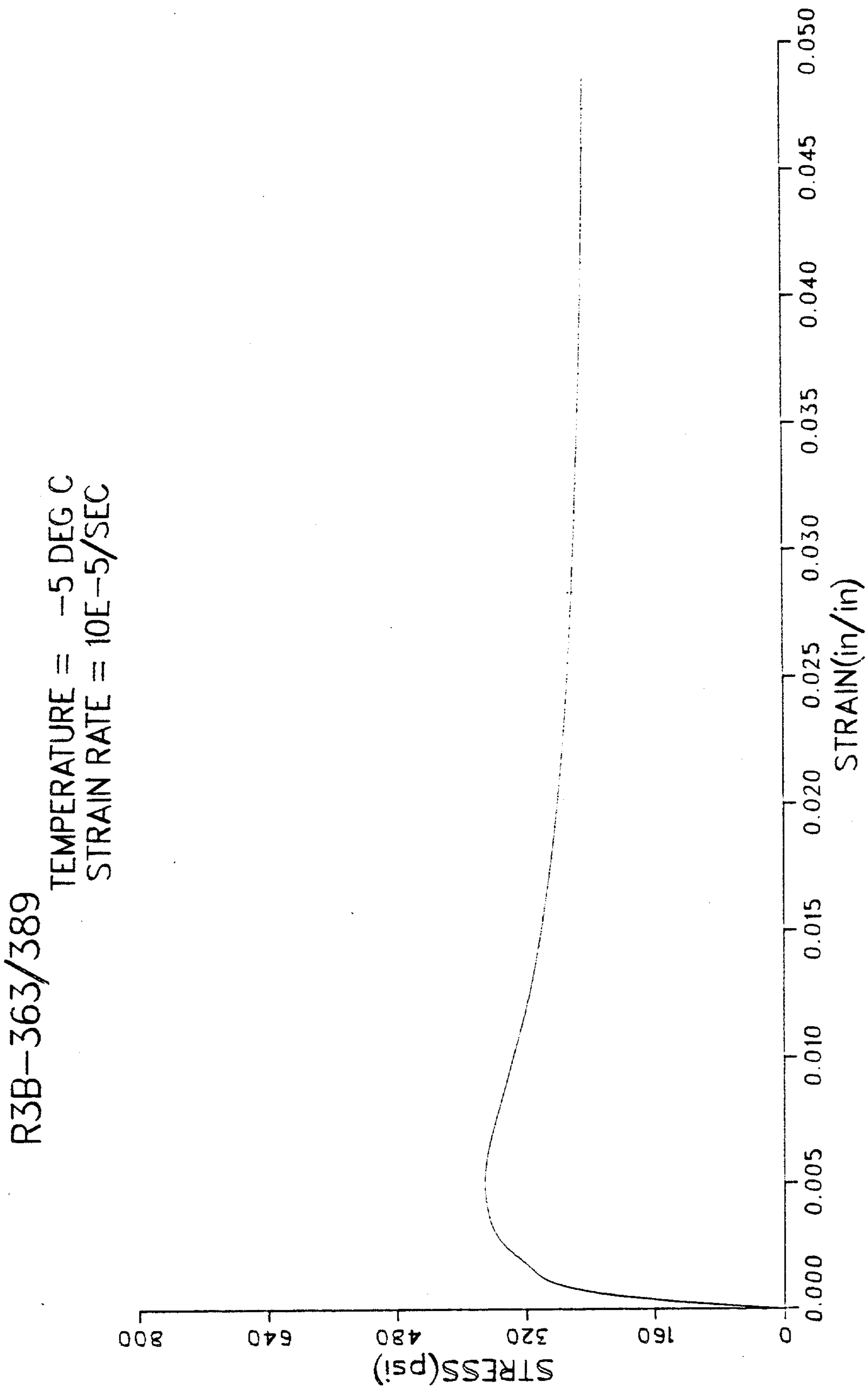

R2A–314/339
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

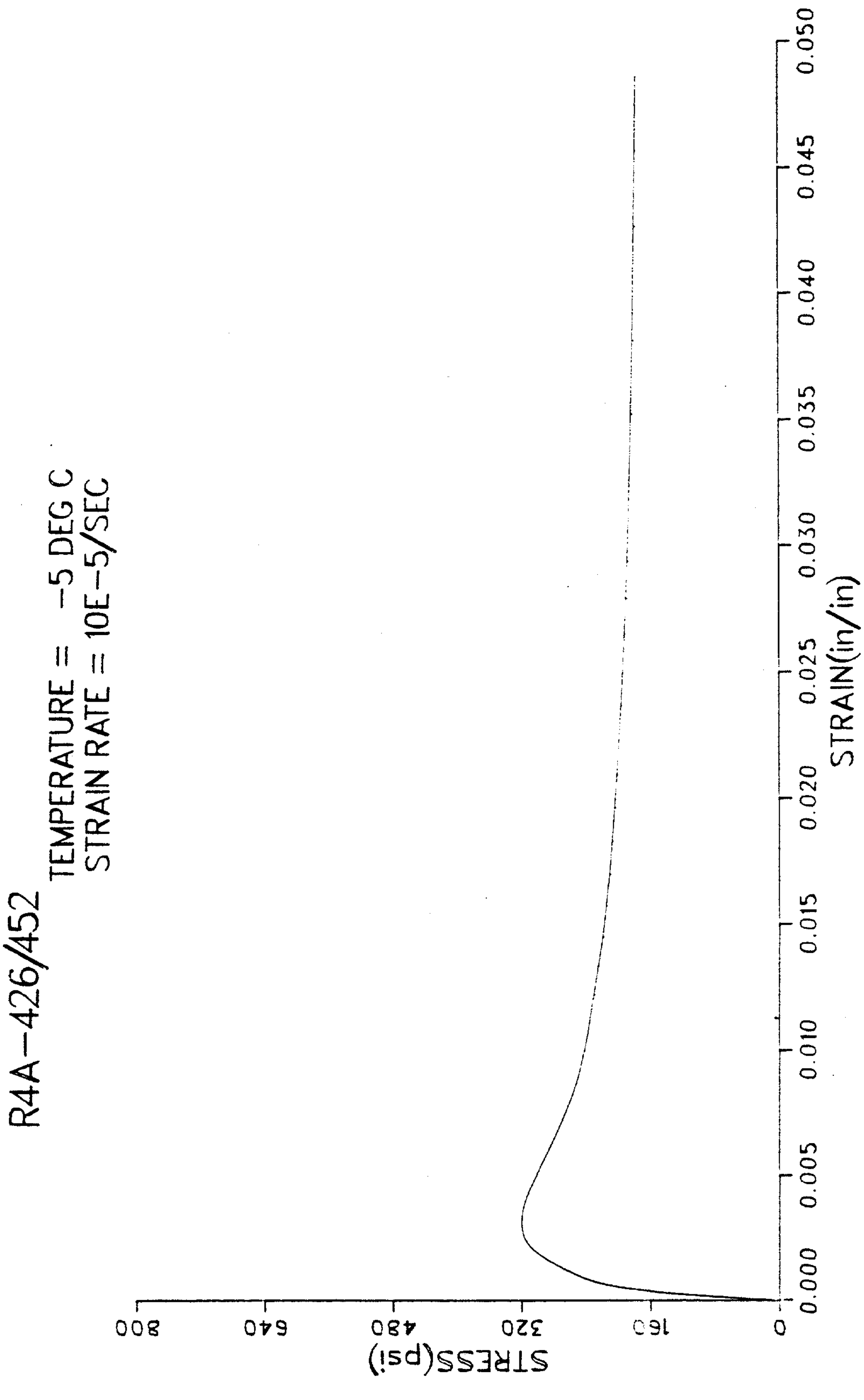

R2B-408/434
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

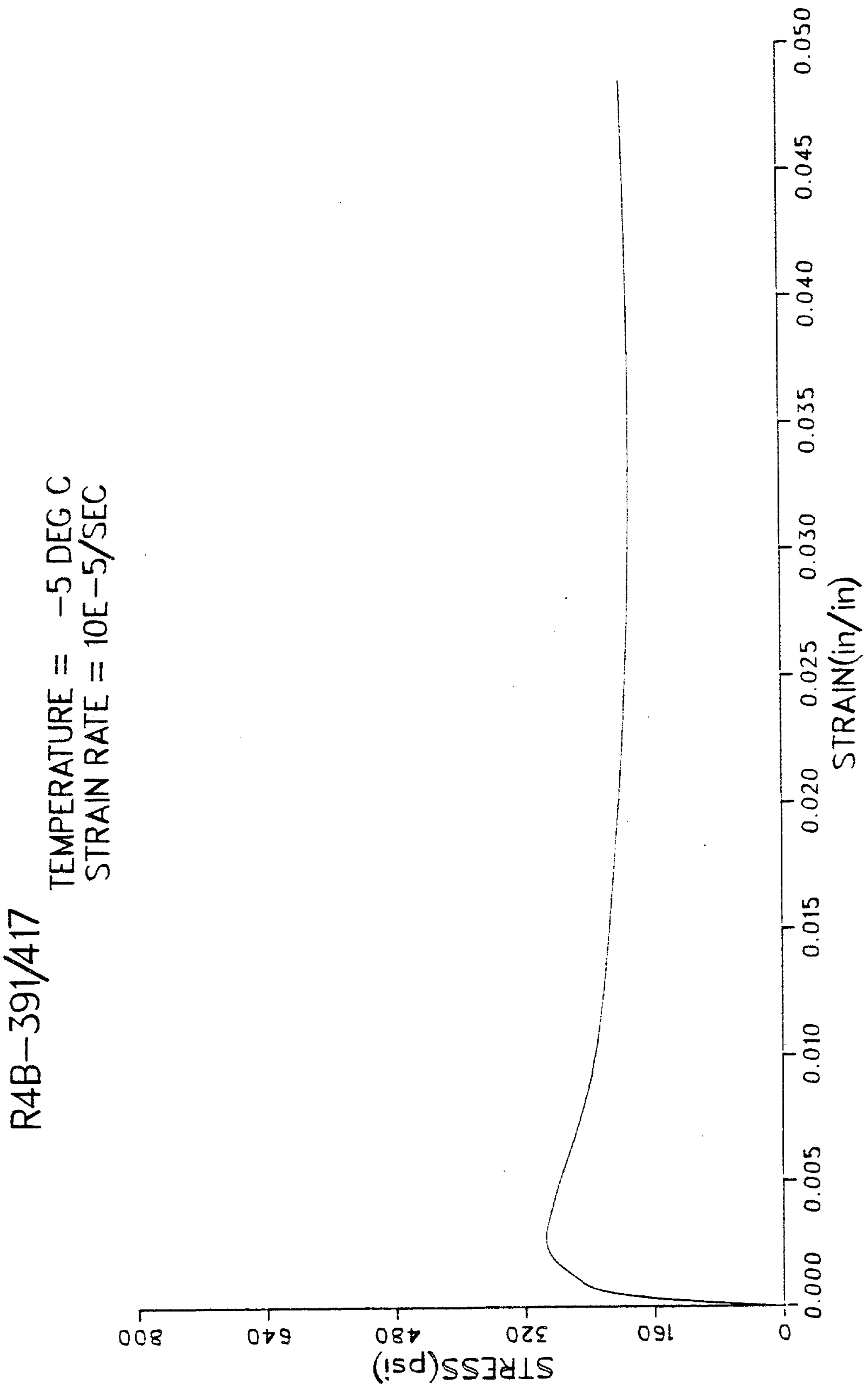

R2B-468/494
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

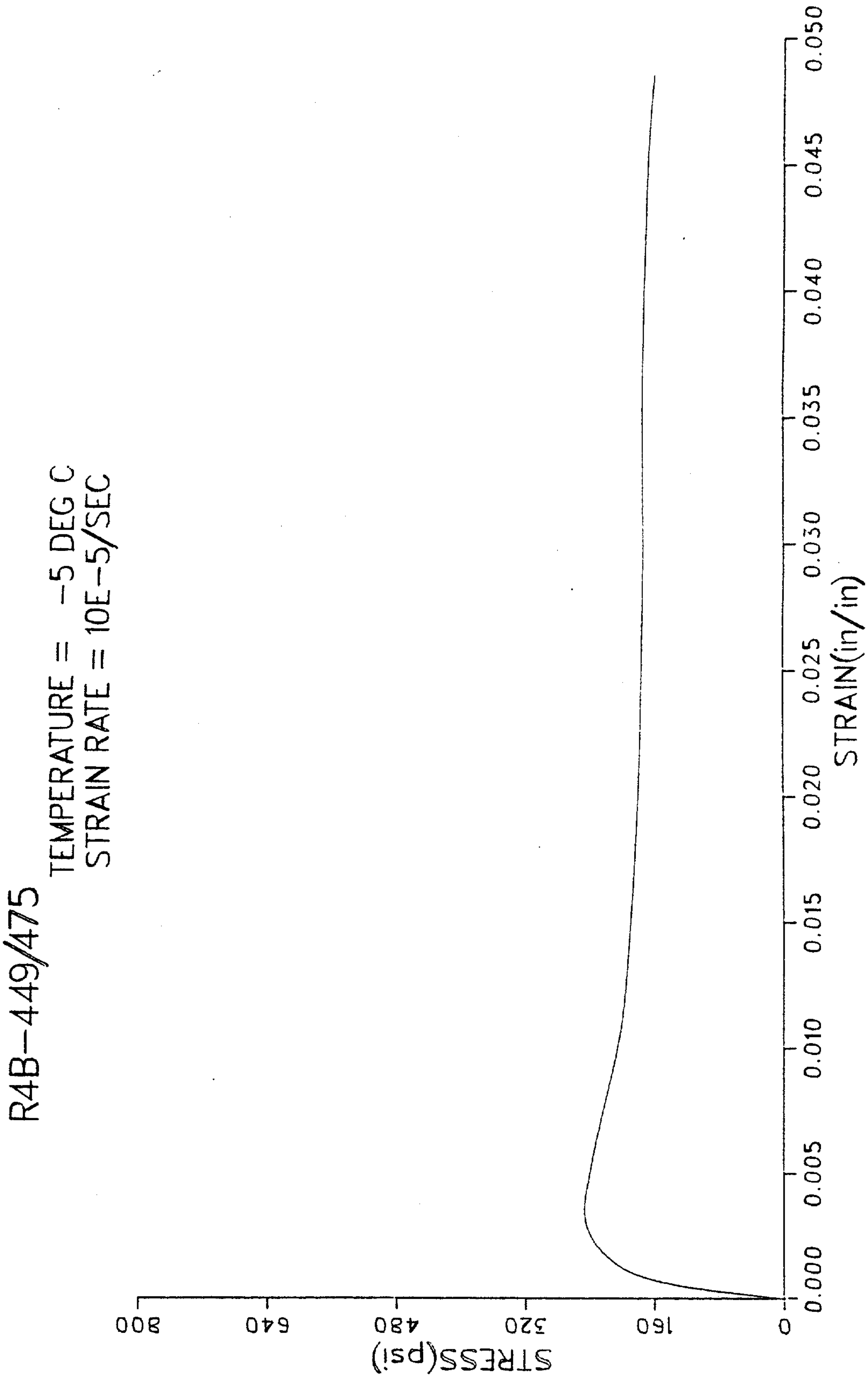

R3A-220/245
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

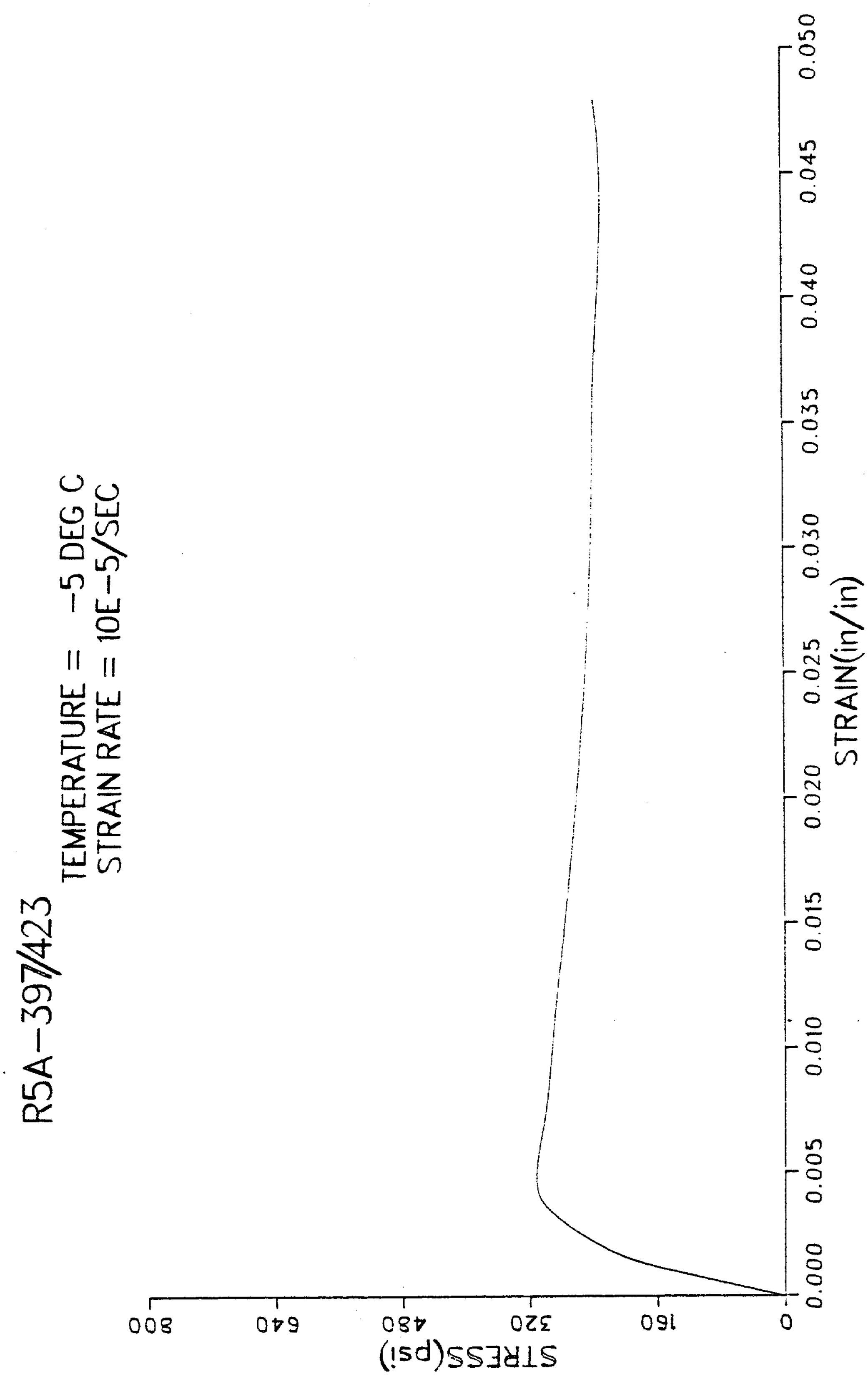

R3A-430/456
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

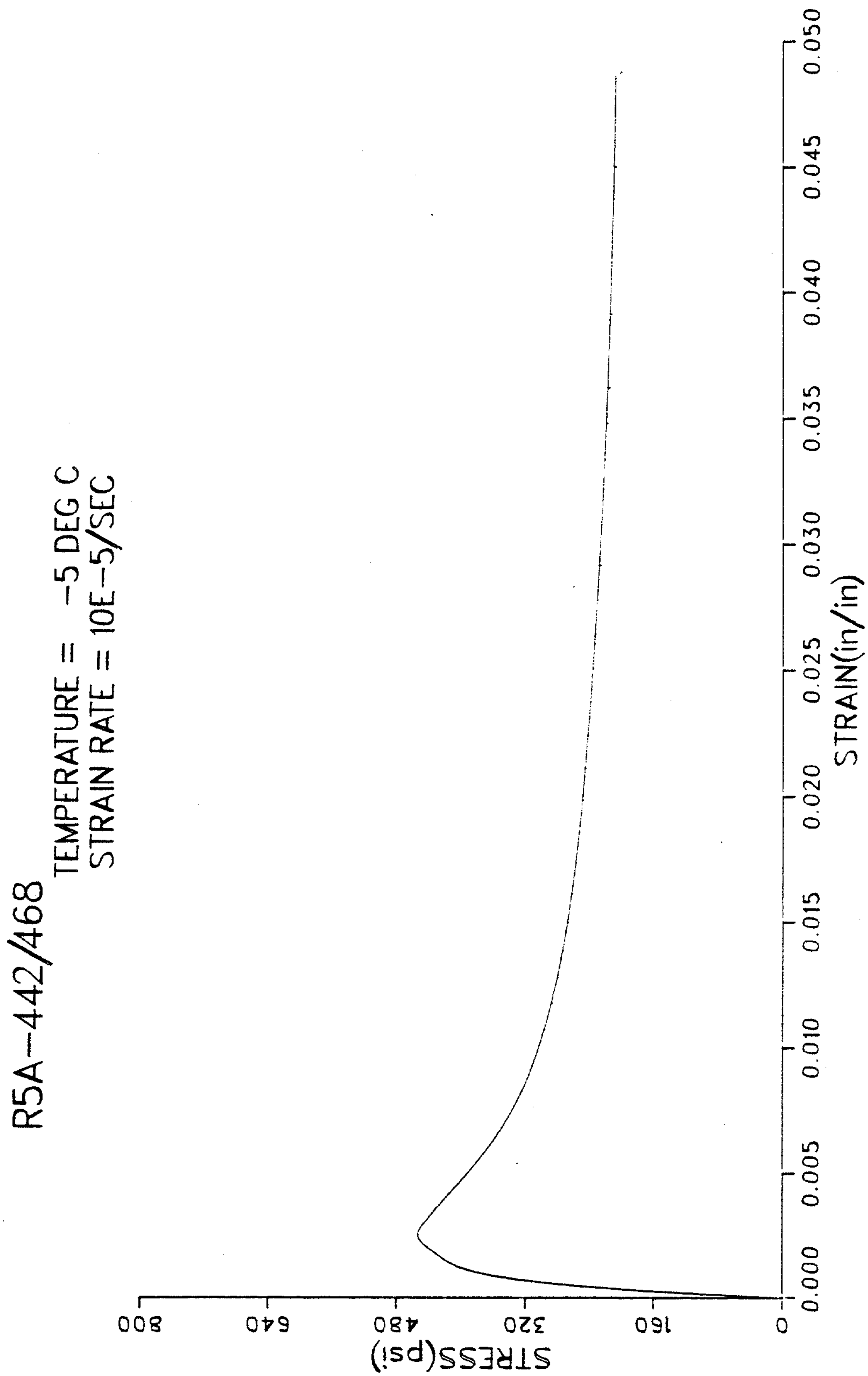

R3B-363/389
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

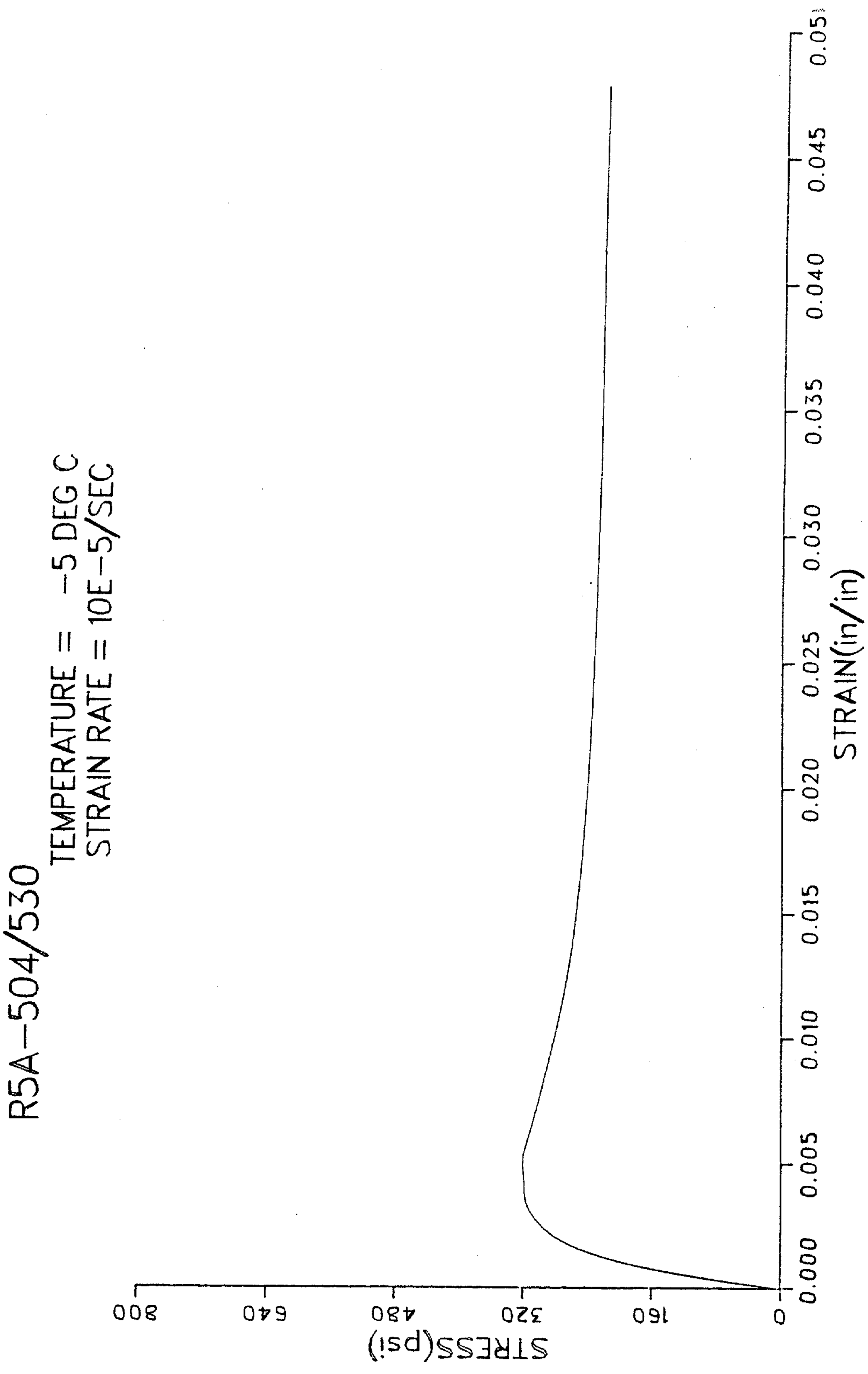

R4A-426/452
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000 0.005 0.010 0.015 0.020 0.025 0.030 0.035 0.040 0.045 0.050
STRESS(psi)
0 160 320 480 640 800

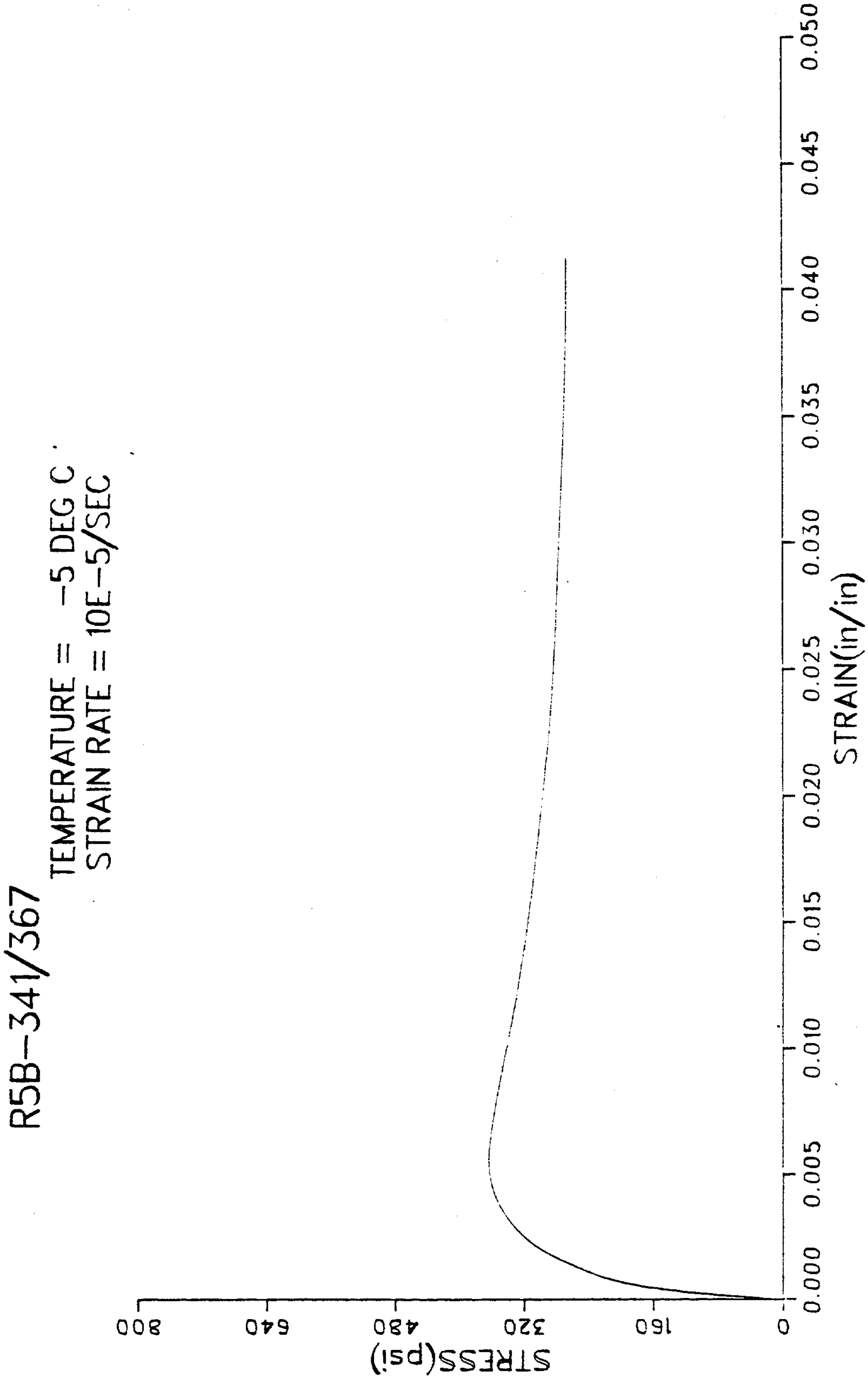

R4B-391/417
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

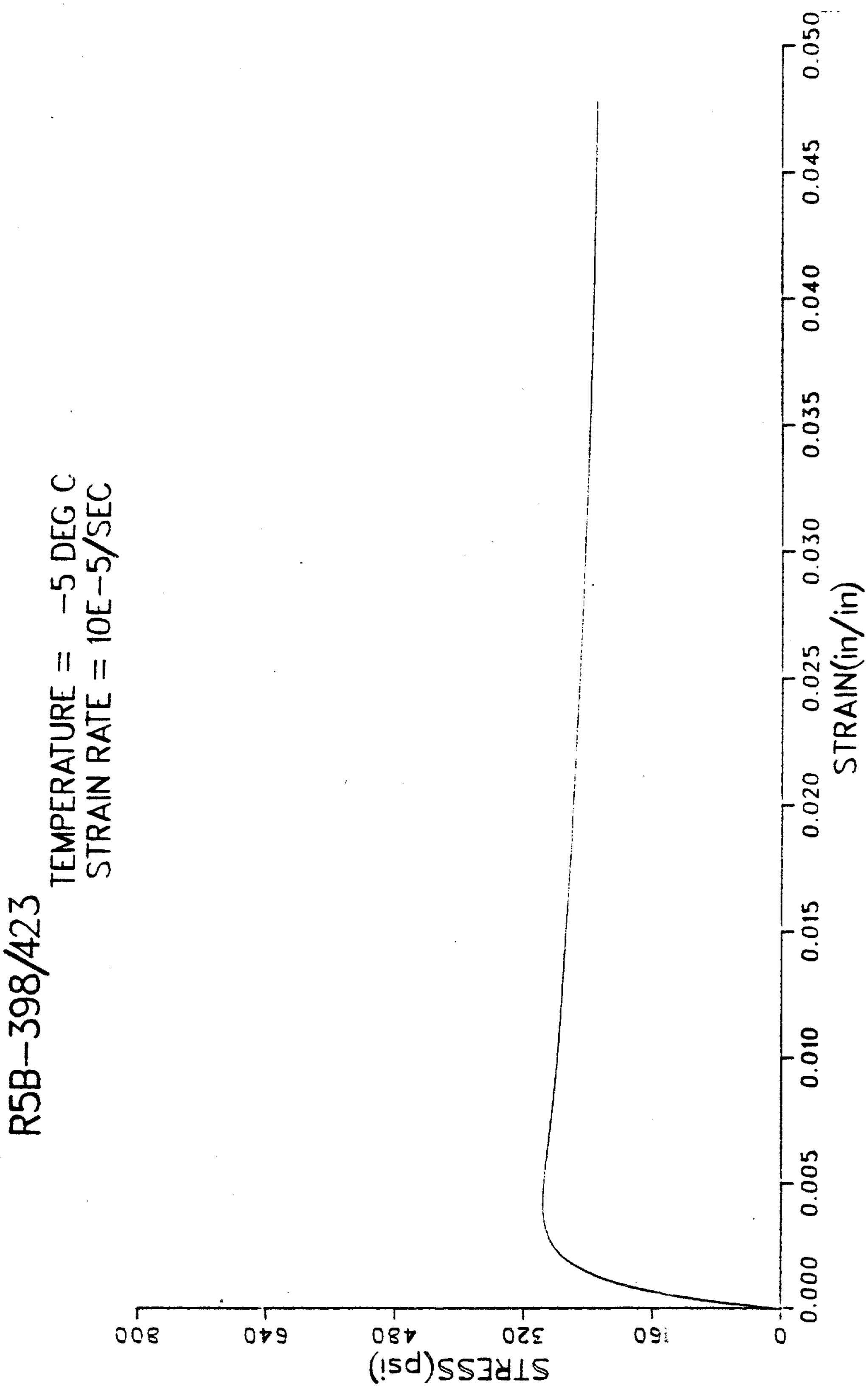

R4B-449/475
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

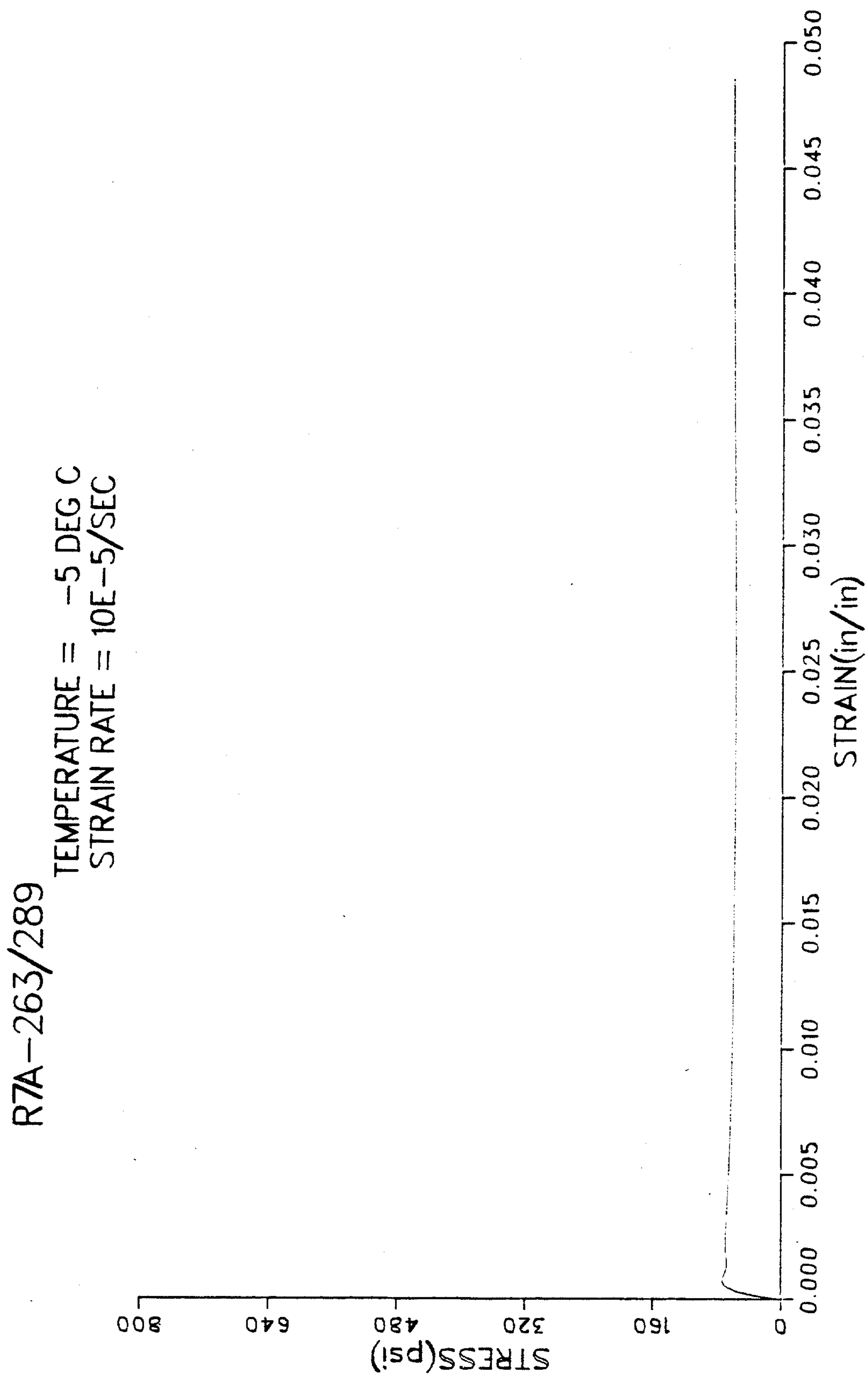

R5A-397/423
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

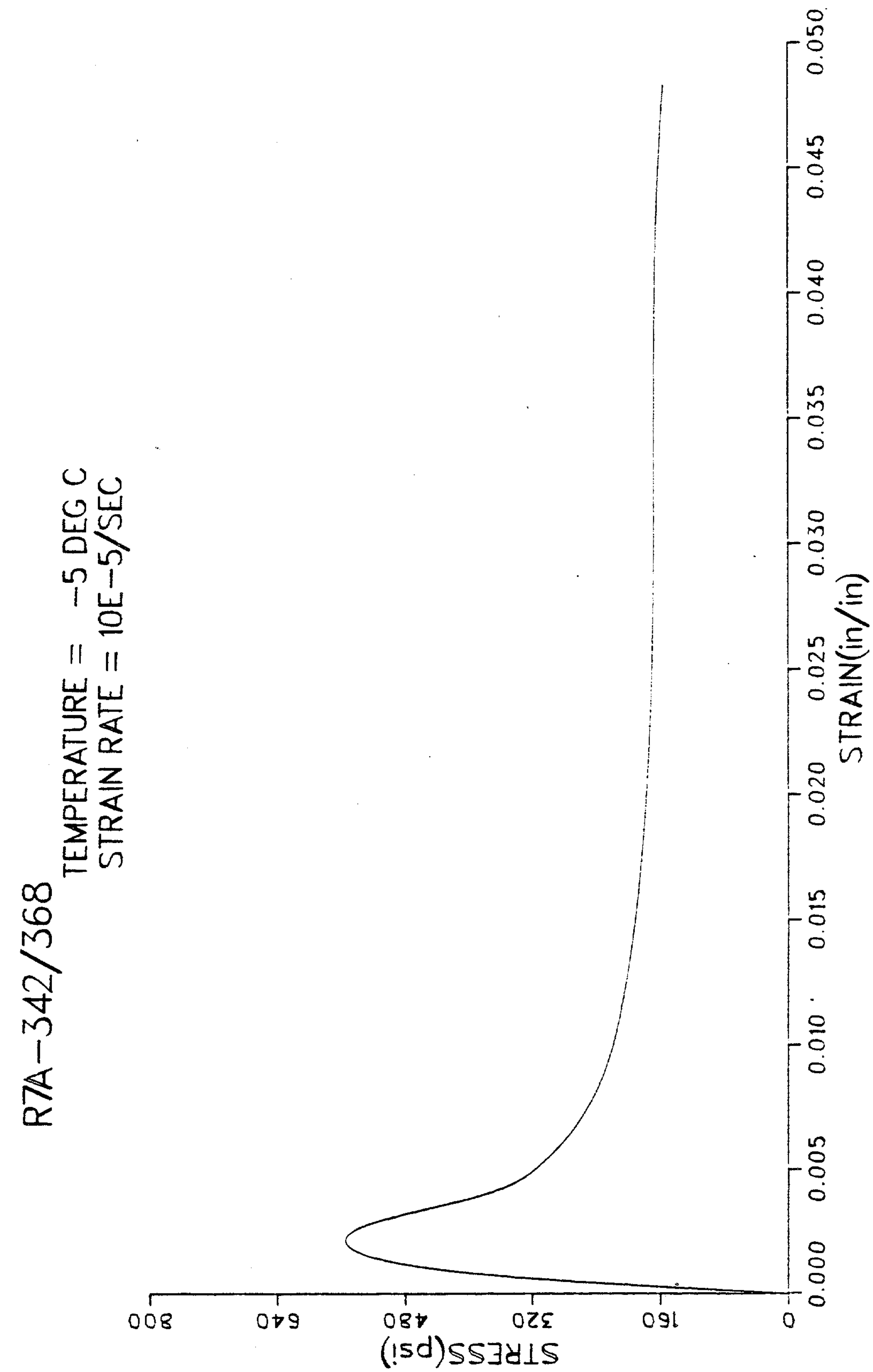

R5A-442/468
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
160
320
480
640
800

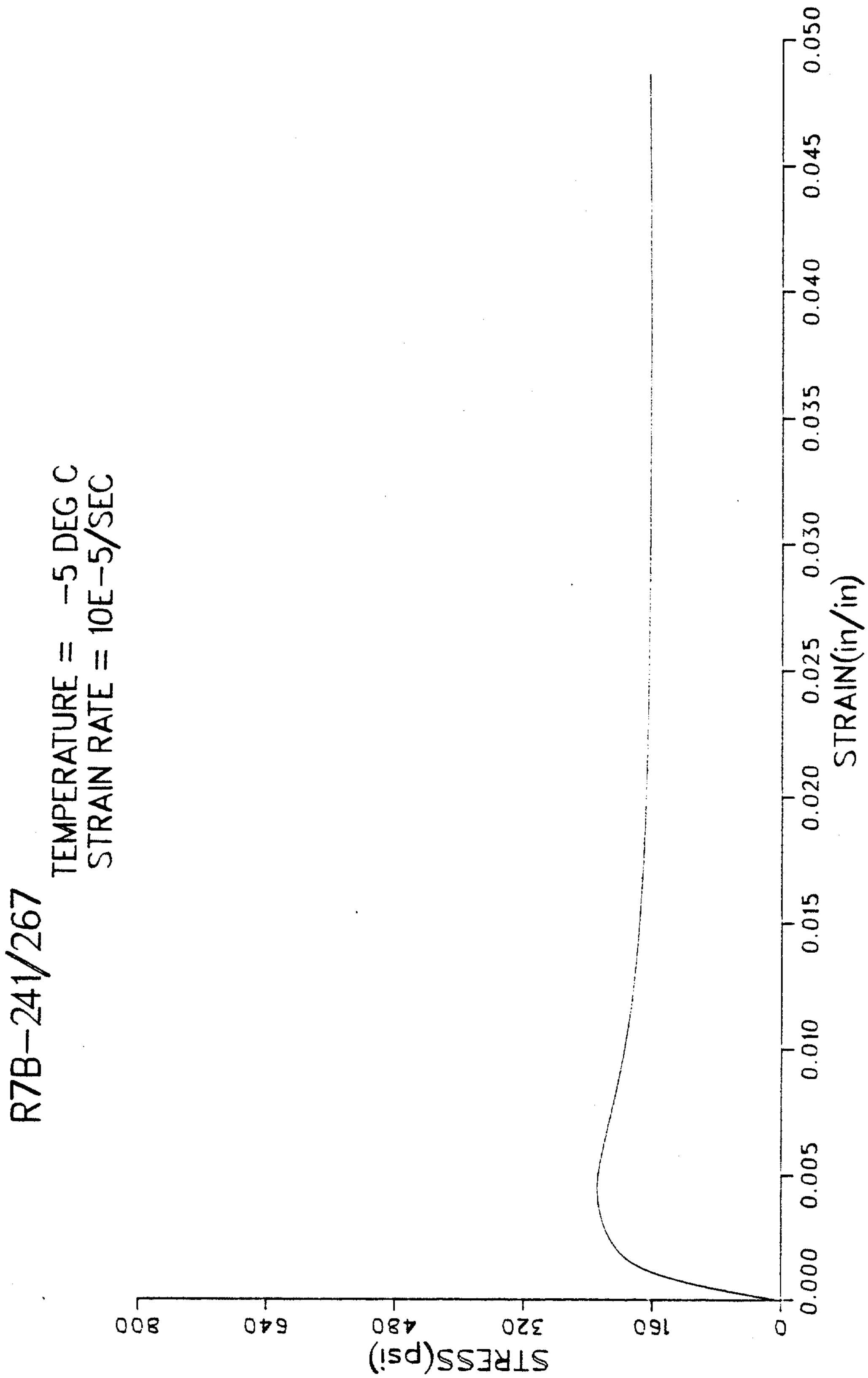

R5A-504/530
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.05
0
160
320
480
640
800

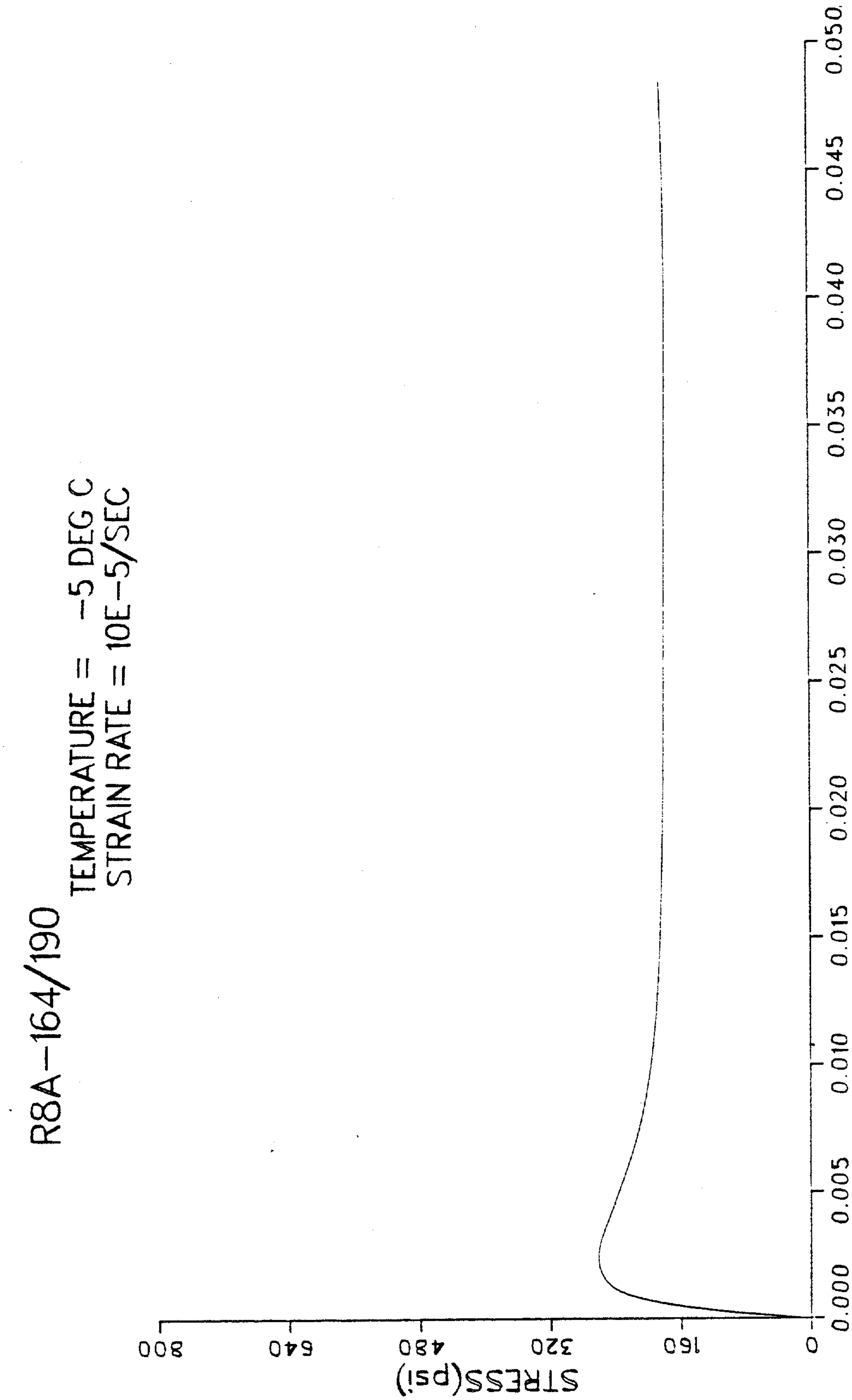

R5B–341/367
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

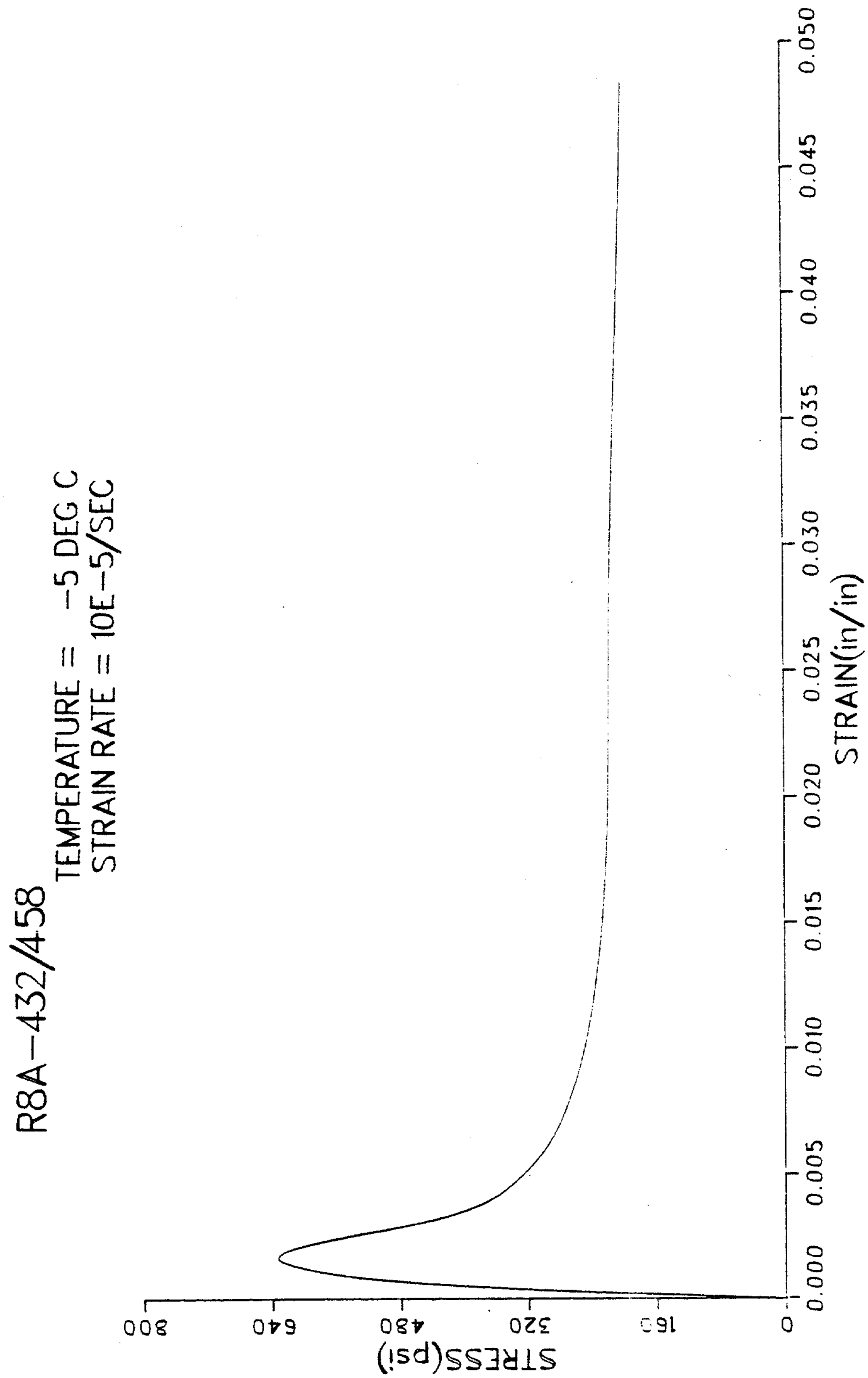

R5B-398/423
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

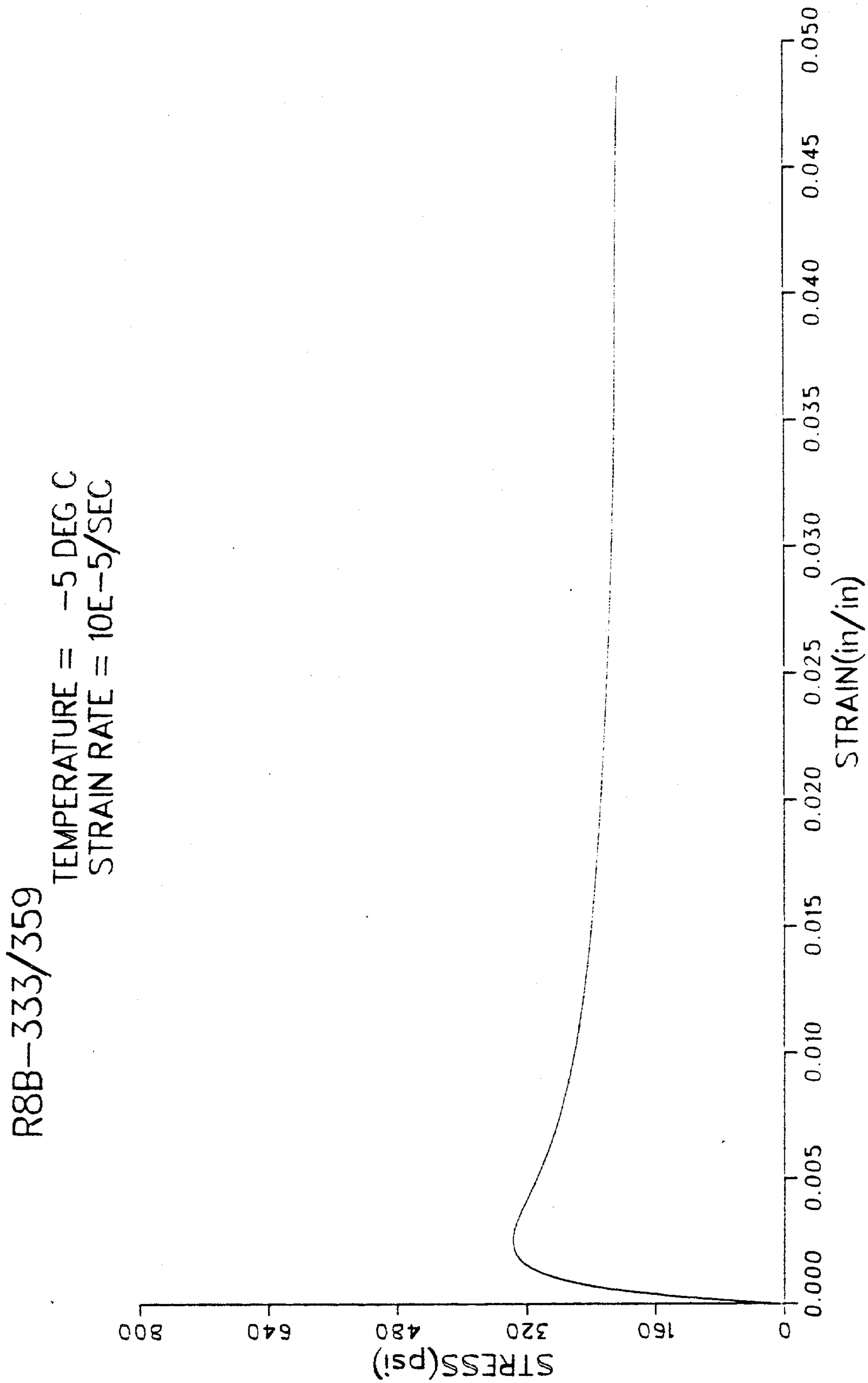

R7A-263/289
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

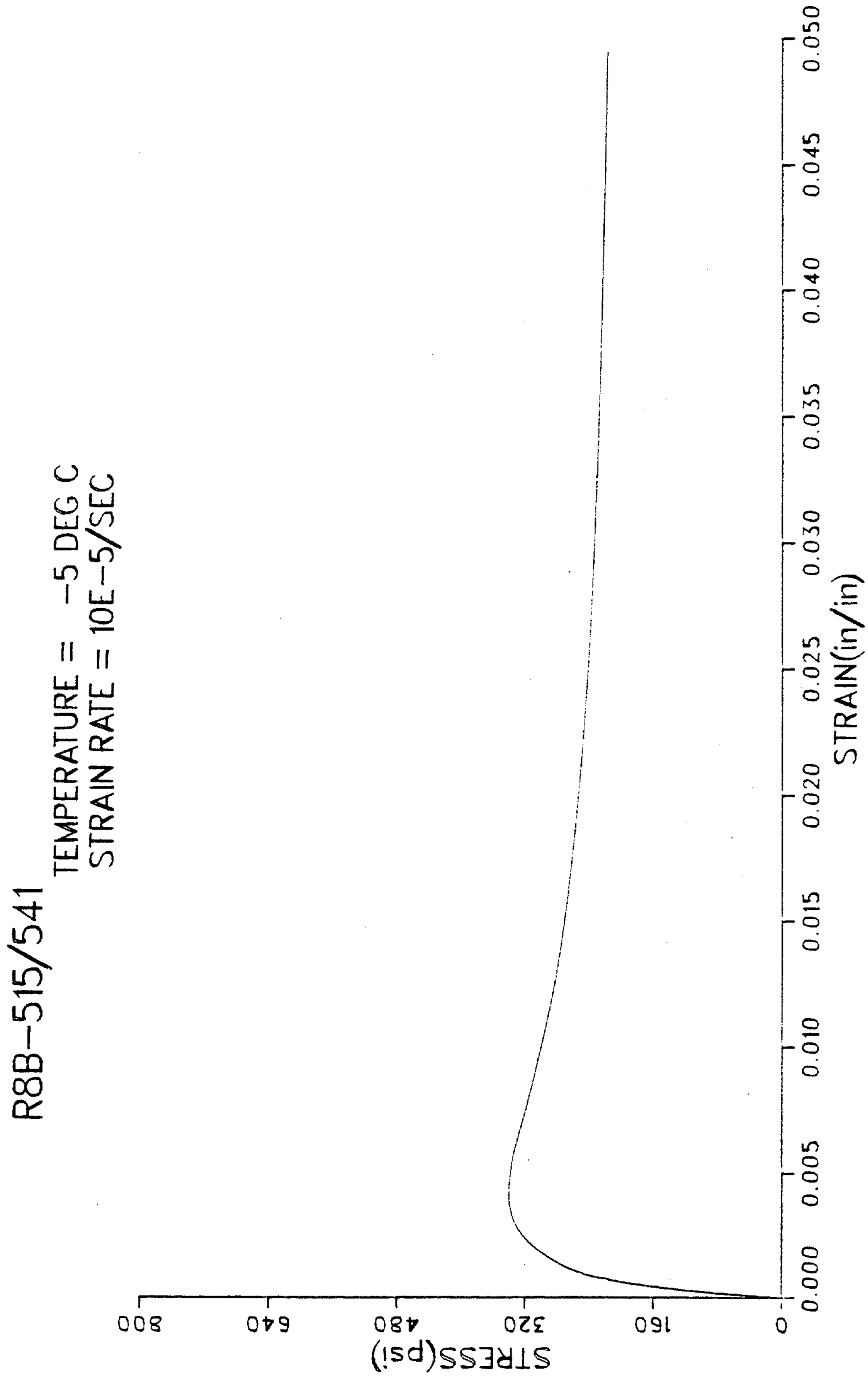

R7A-342/368
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

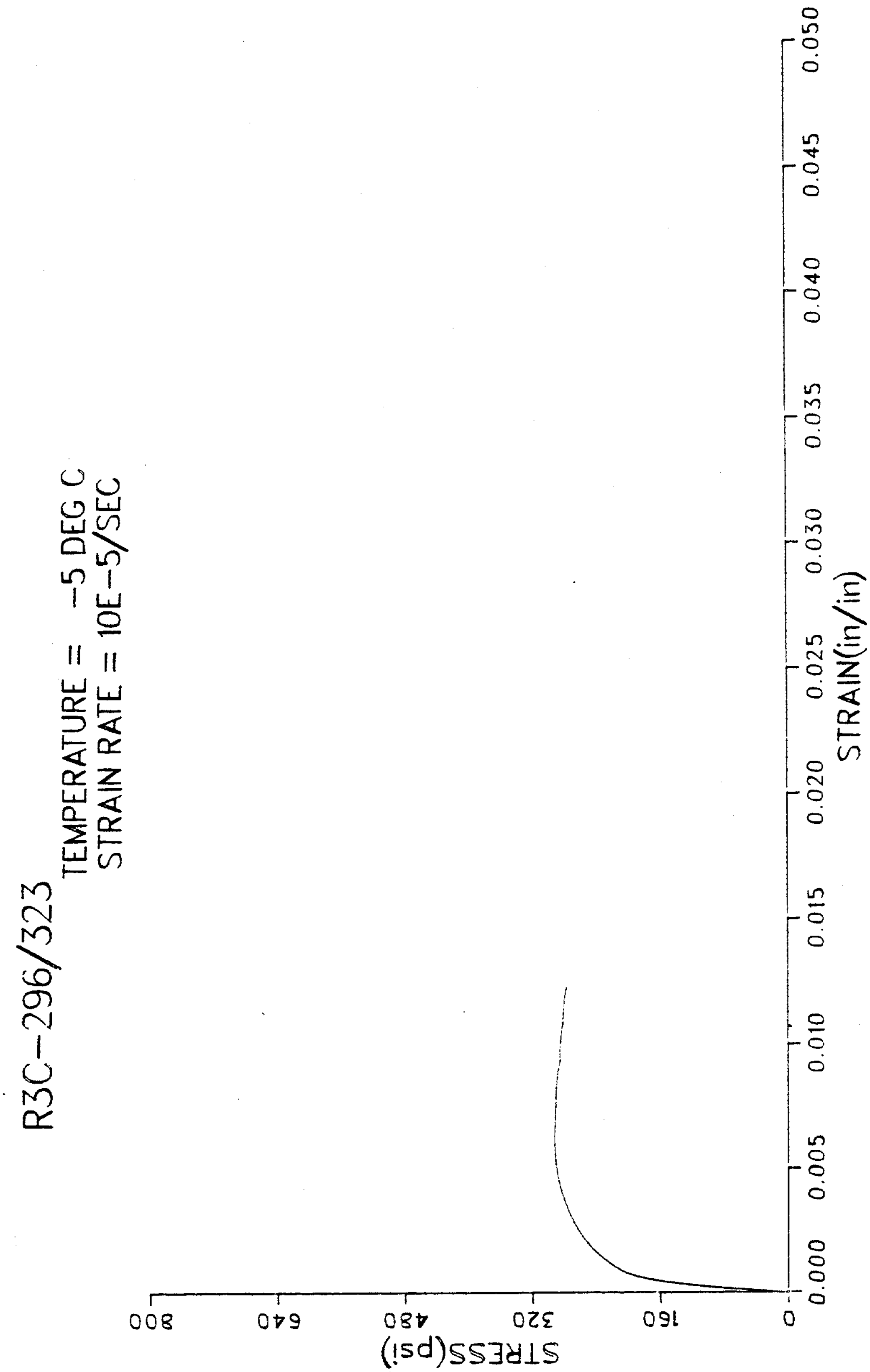

R7B-241/267
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

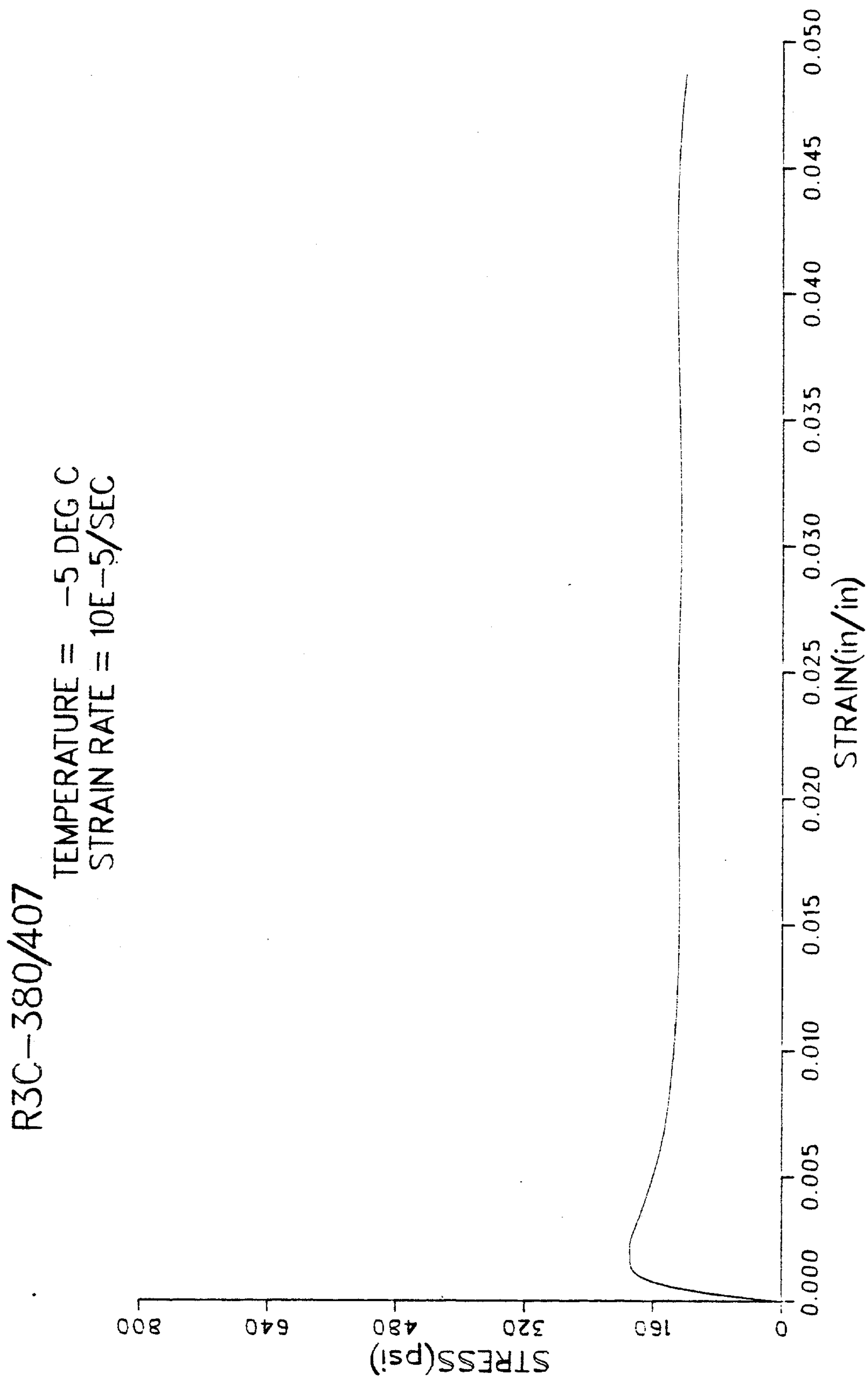

R8A-164/190
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

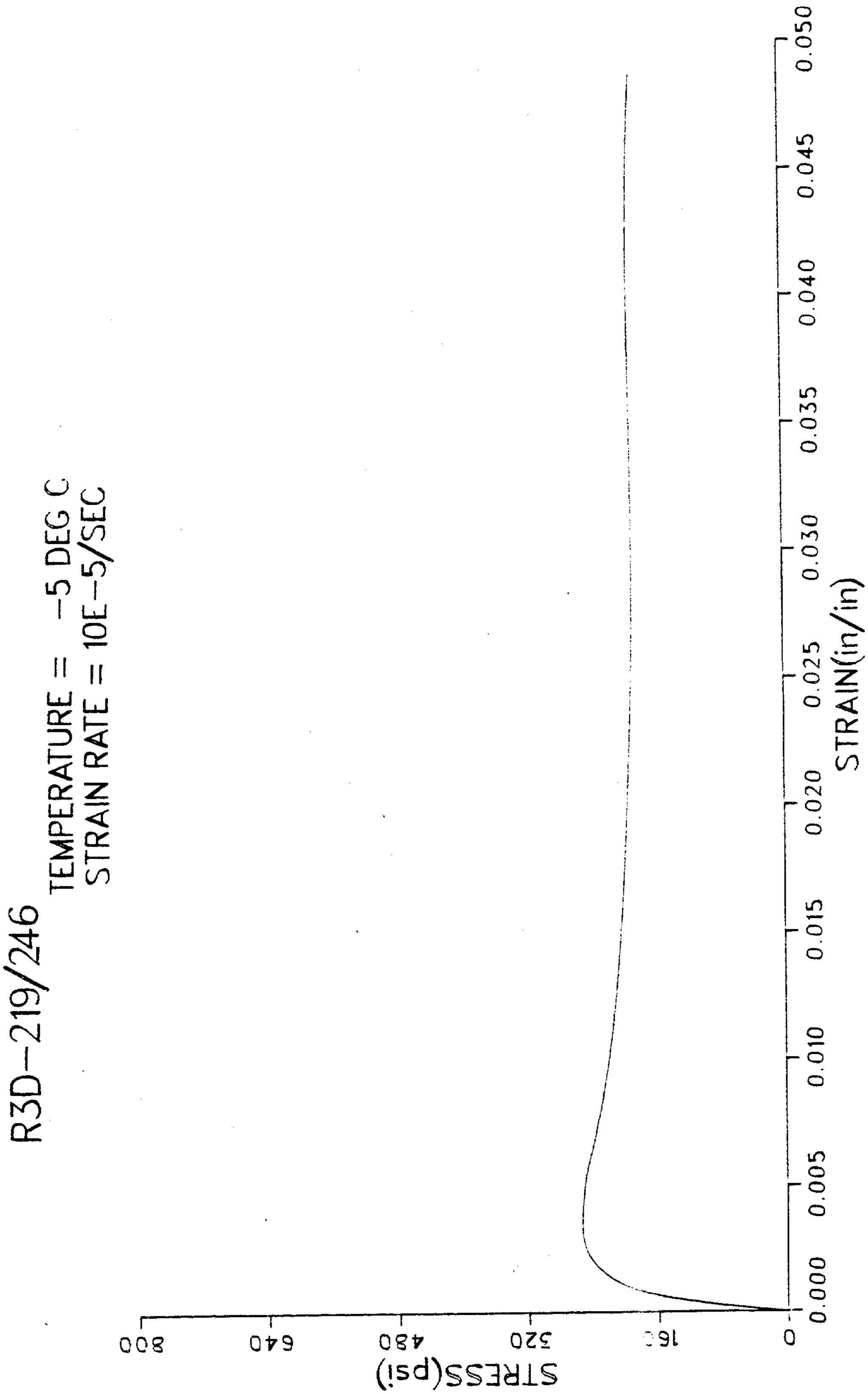

R8A-432/458
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

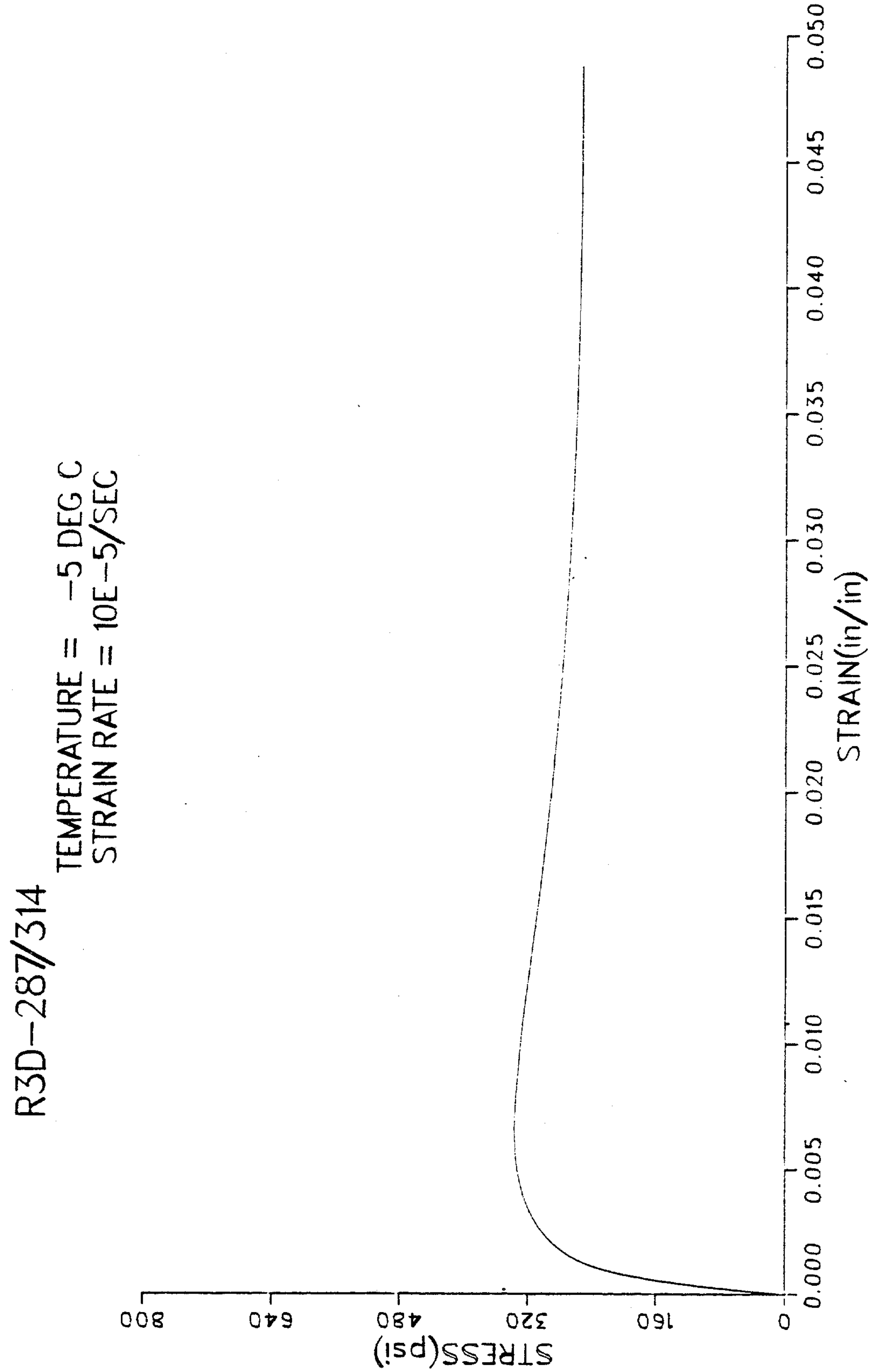

R8B-333/359
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

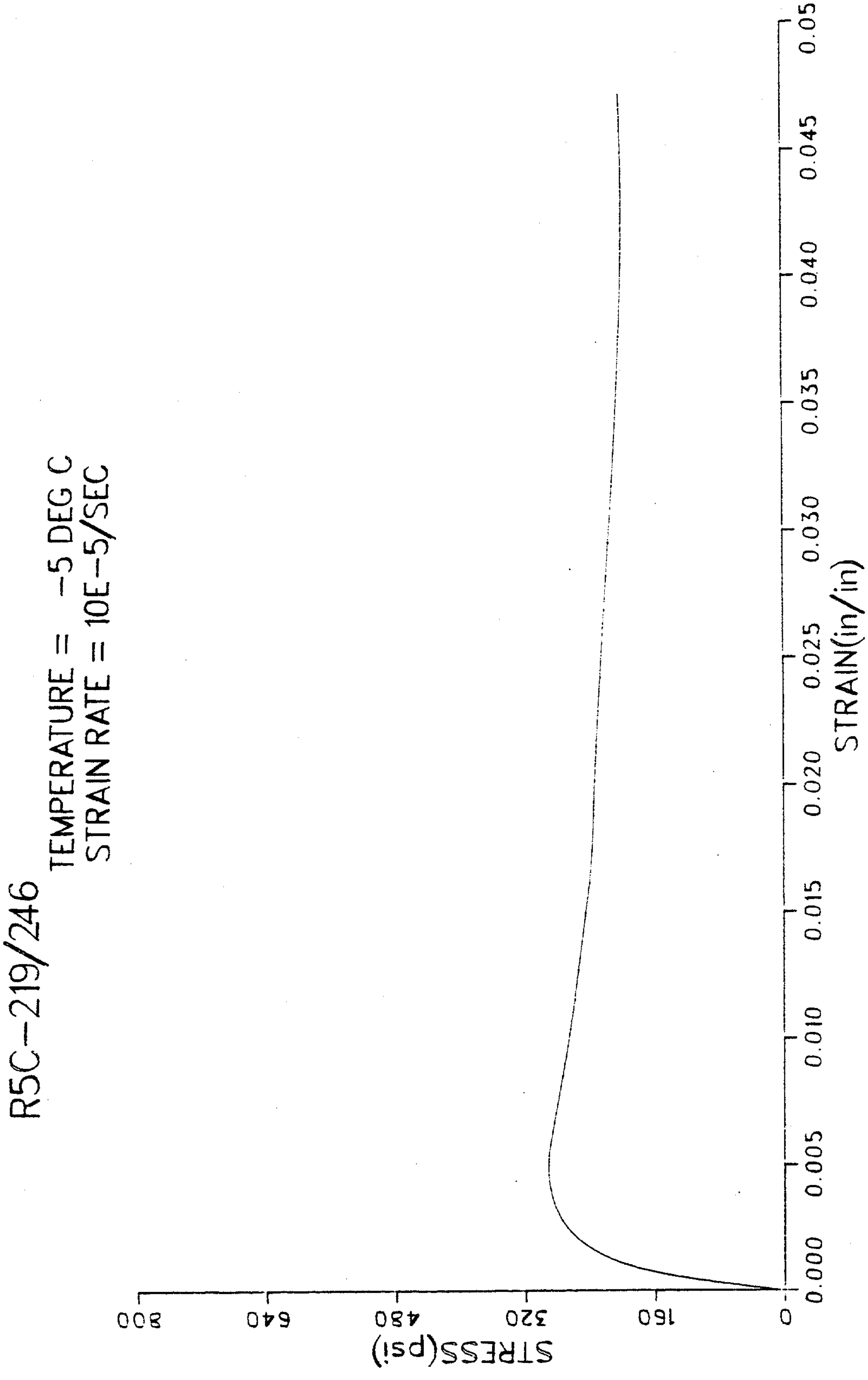

R8B-515/541
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

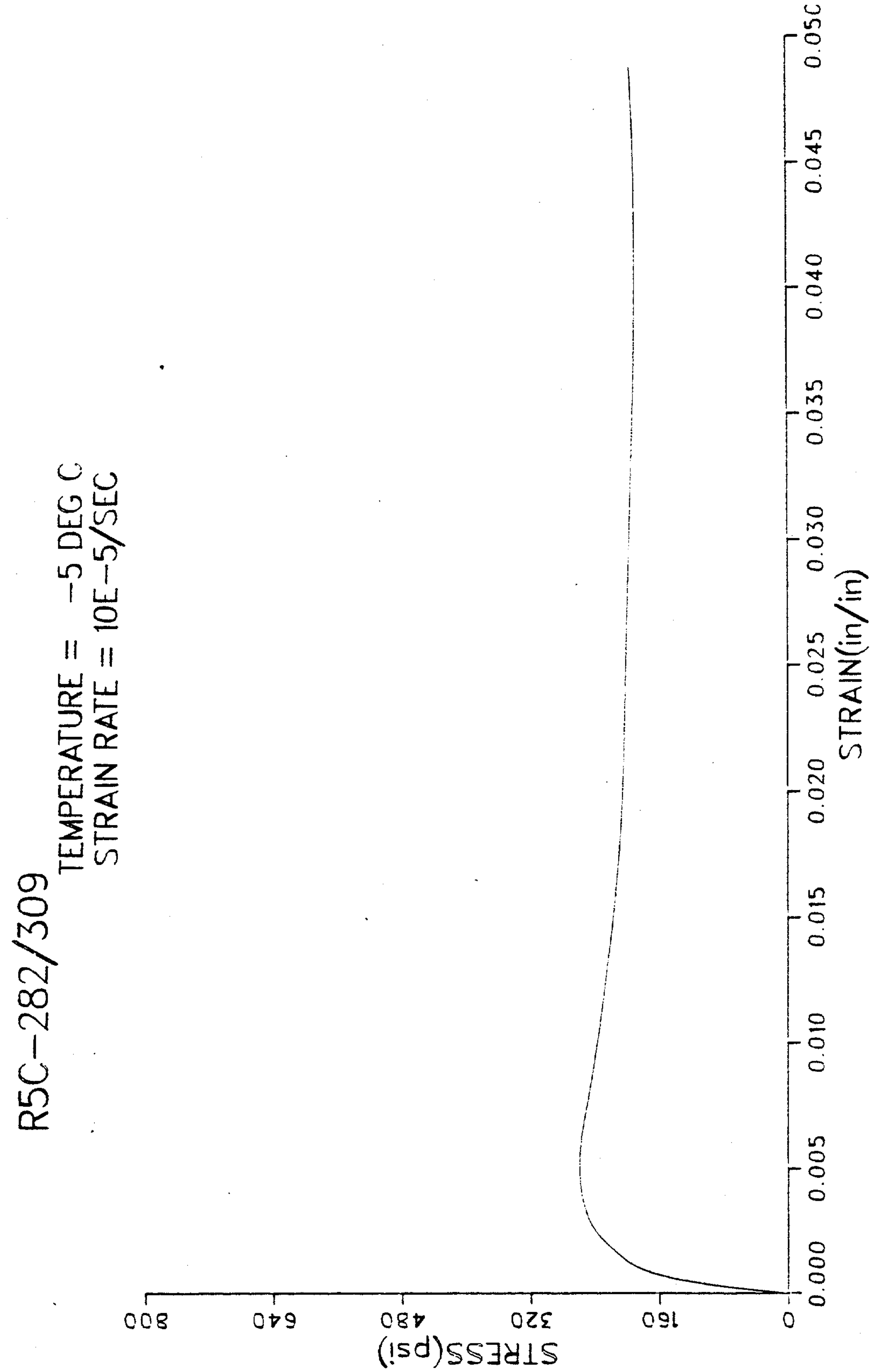

R3C-296/323
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
160
320
480
640
800

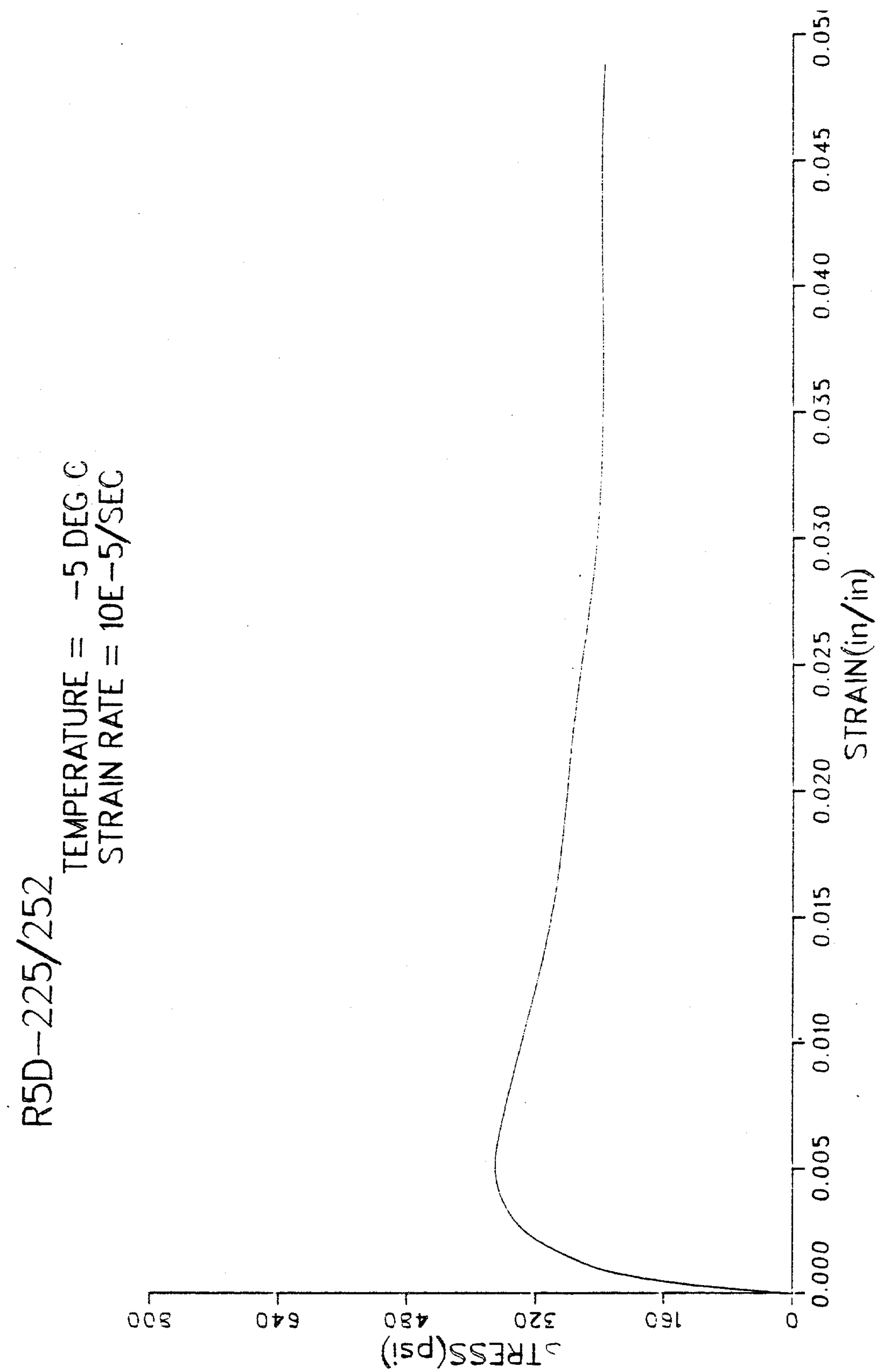

R3C-380/407
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

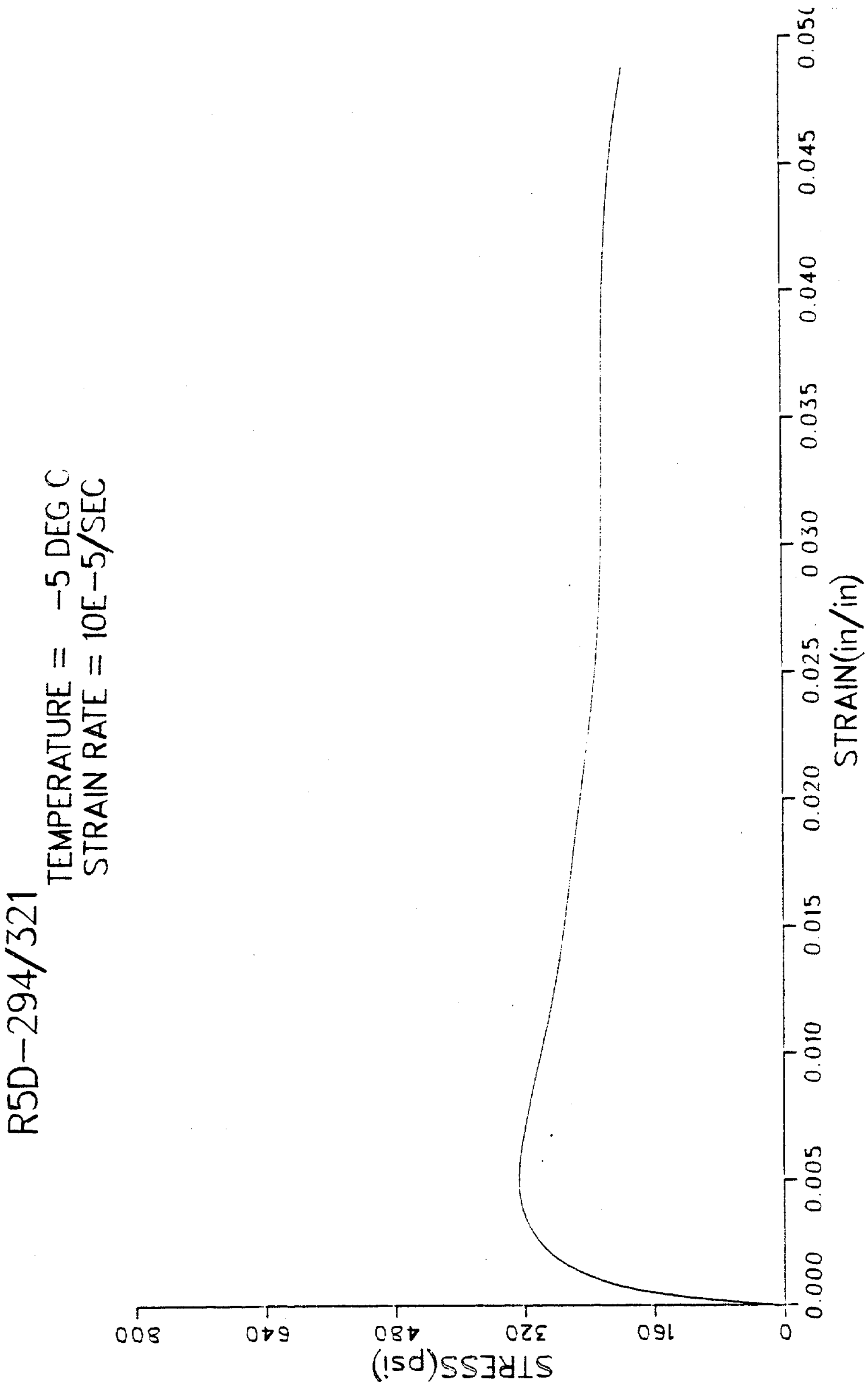

R3D−219/246
TEMPERATURE = −5 DEG C
STRAIN RATE = 10E−5/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
160
320
480
640
800

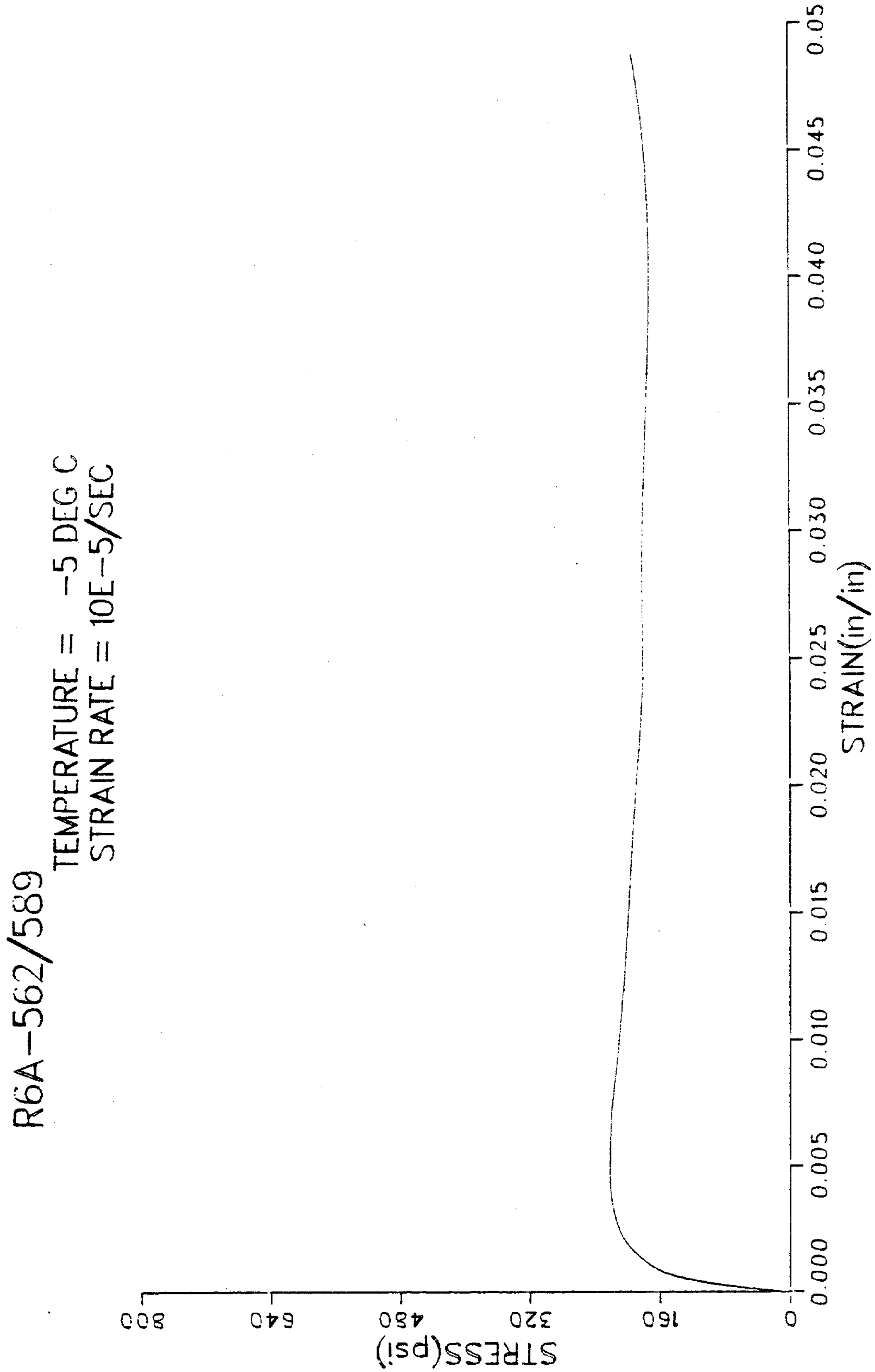

R3D-287/314
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

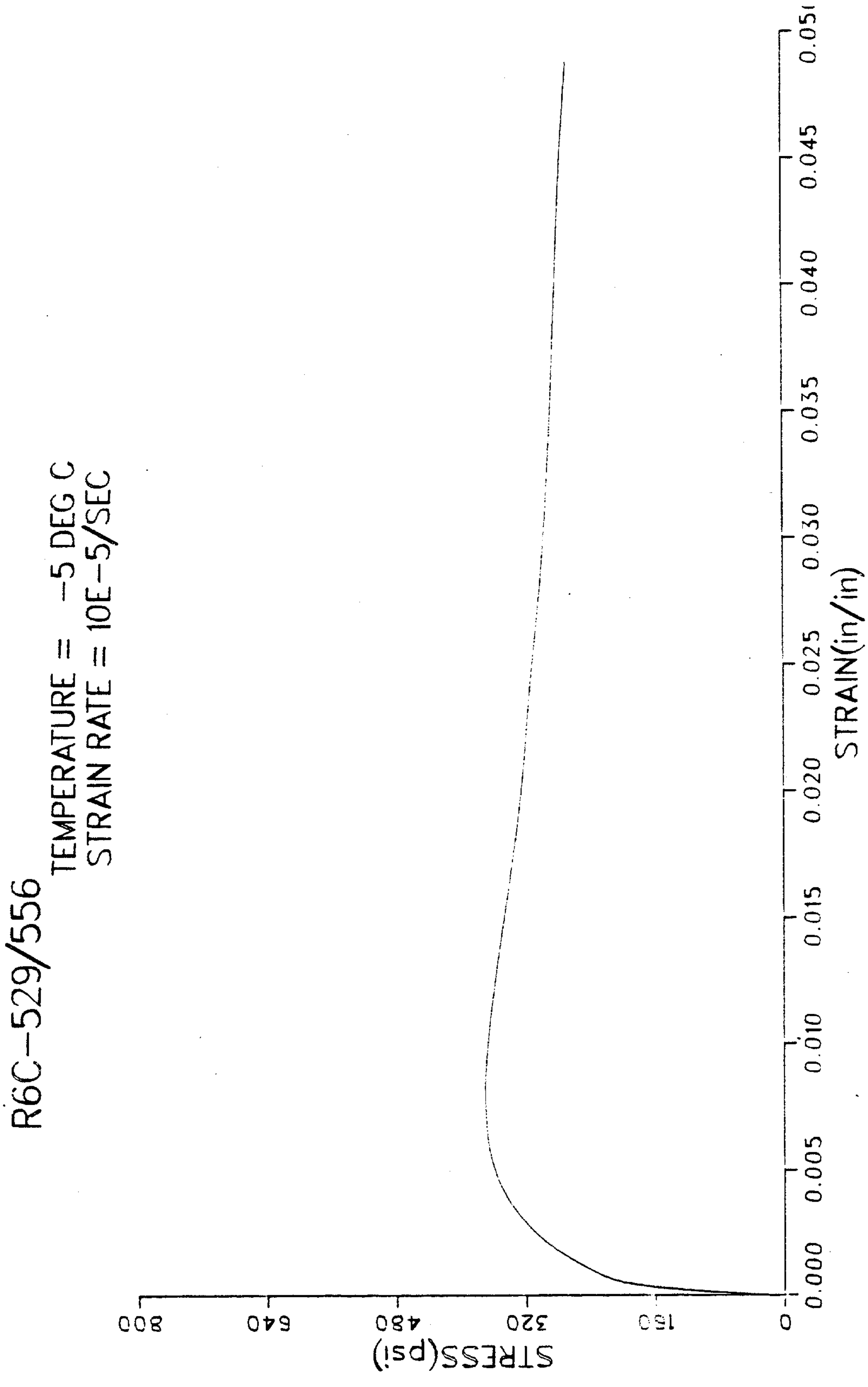

R5C-219/246
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

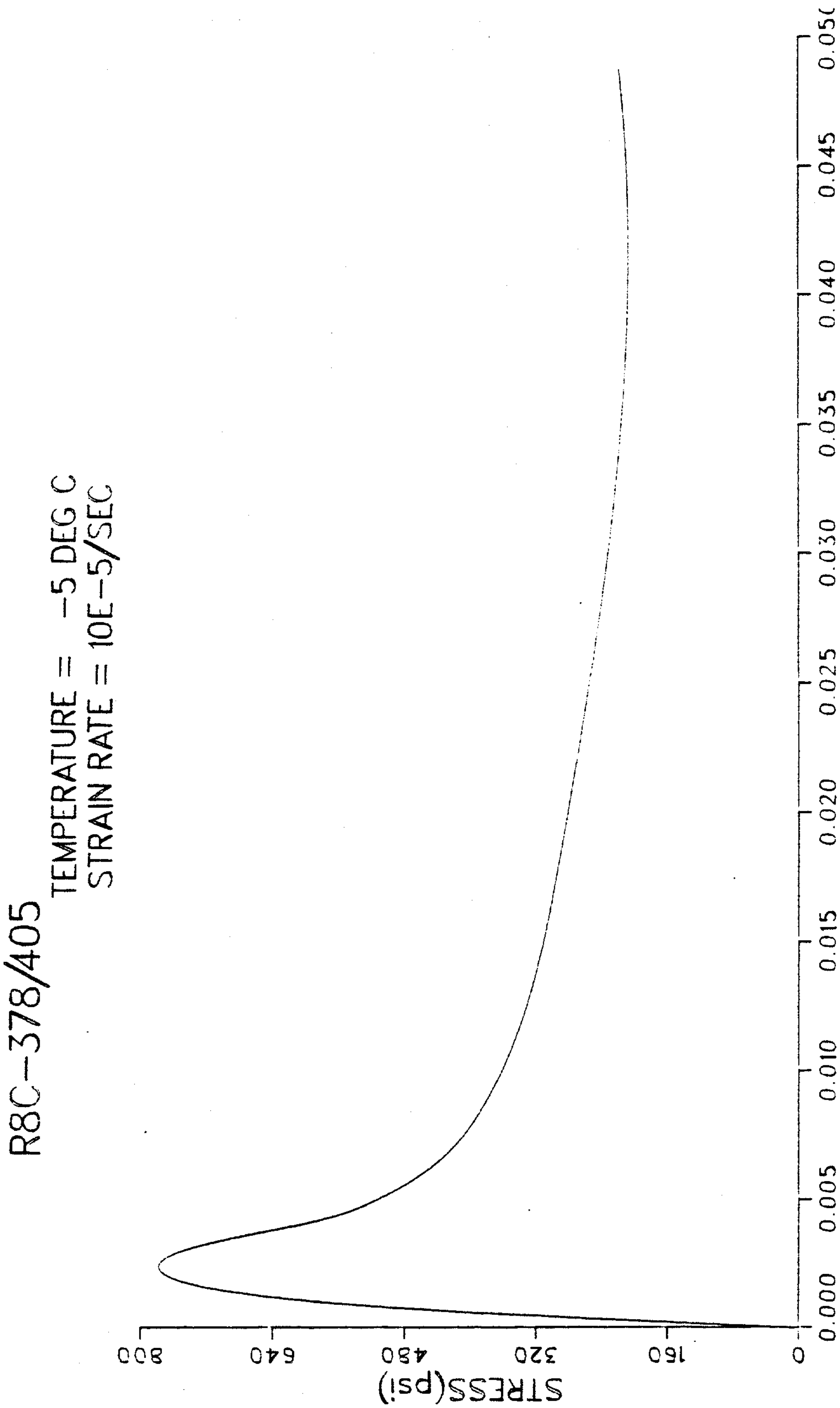

R5C-282/309
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

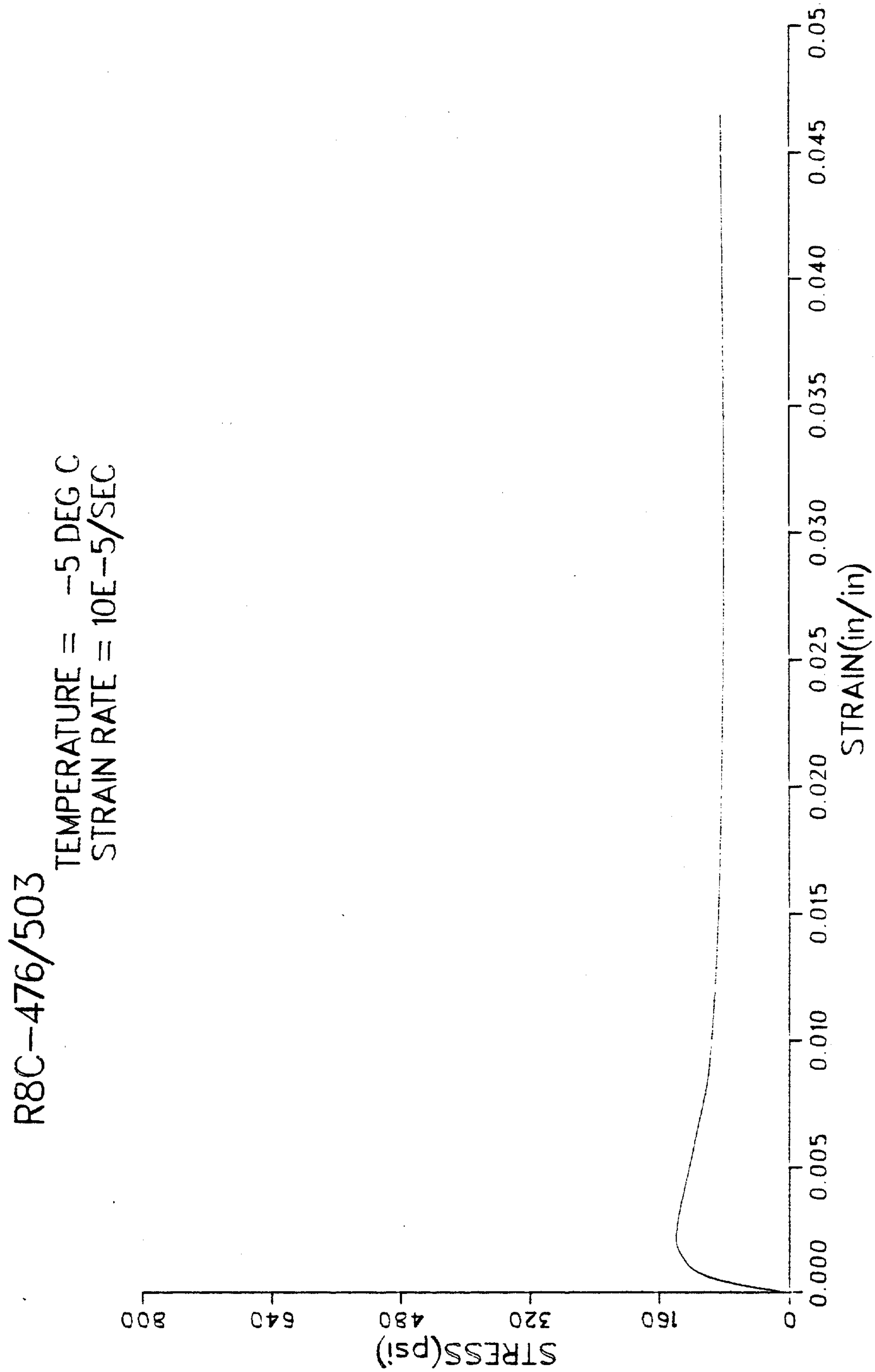

R5D-225/252
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.05
TRESS(psi)
0
160
320
480
640
800

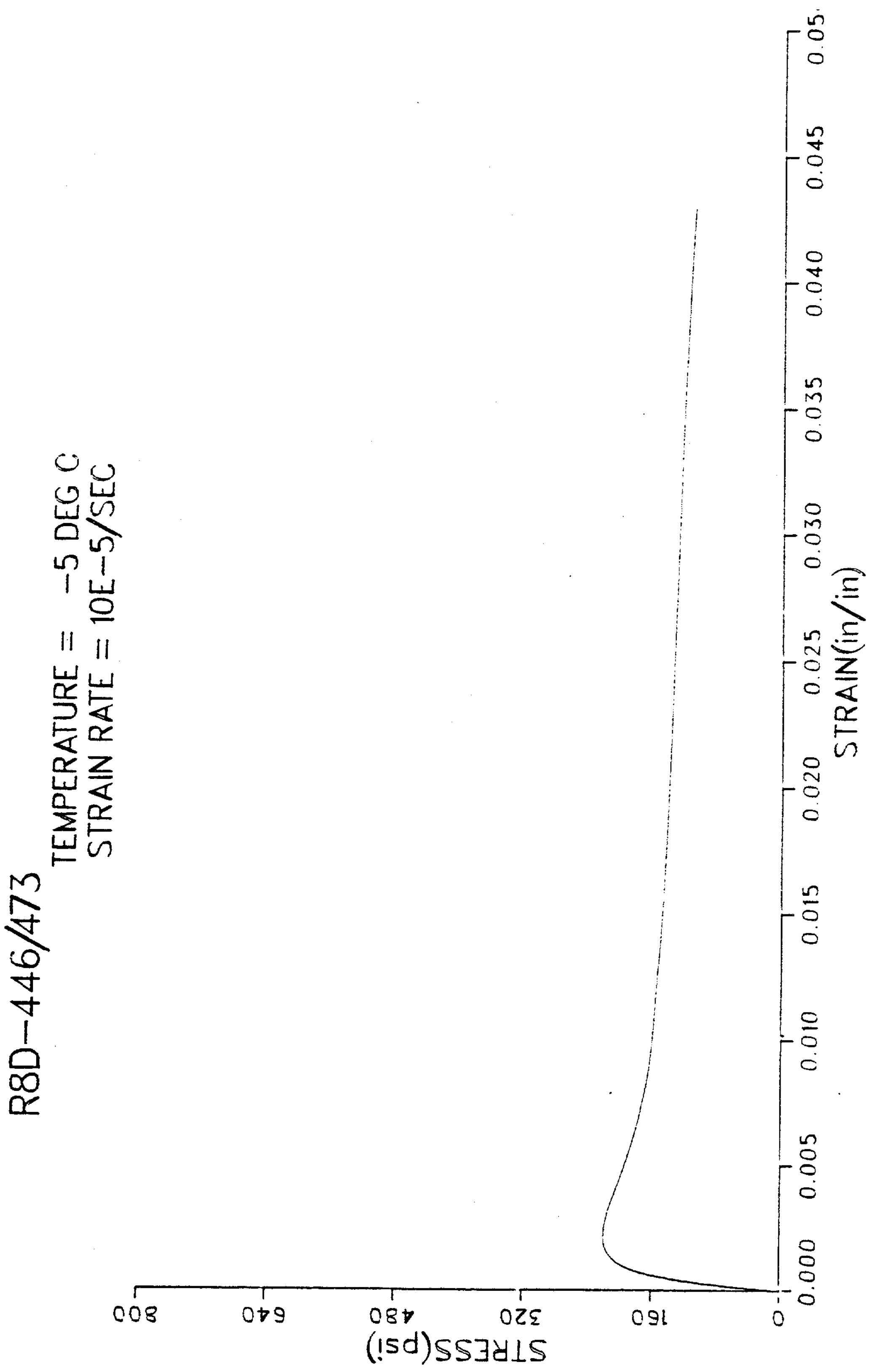

R5D-294/321
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
STRESS(psi)
0
160
320
480
640
800

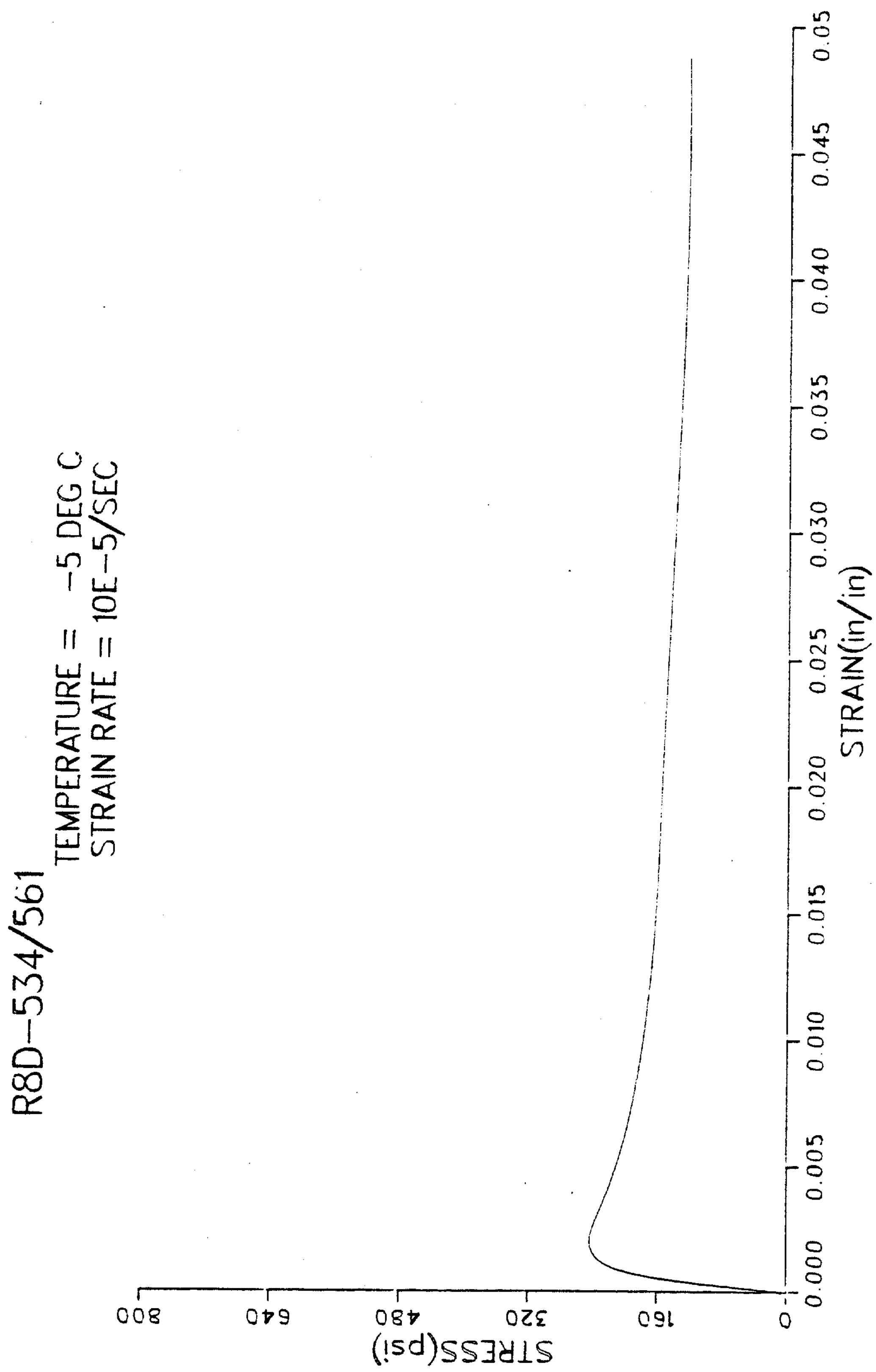

R6A-562/589
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.05

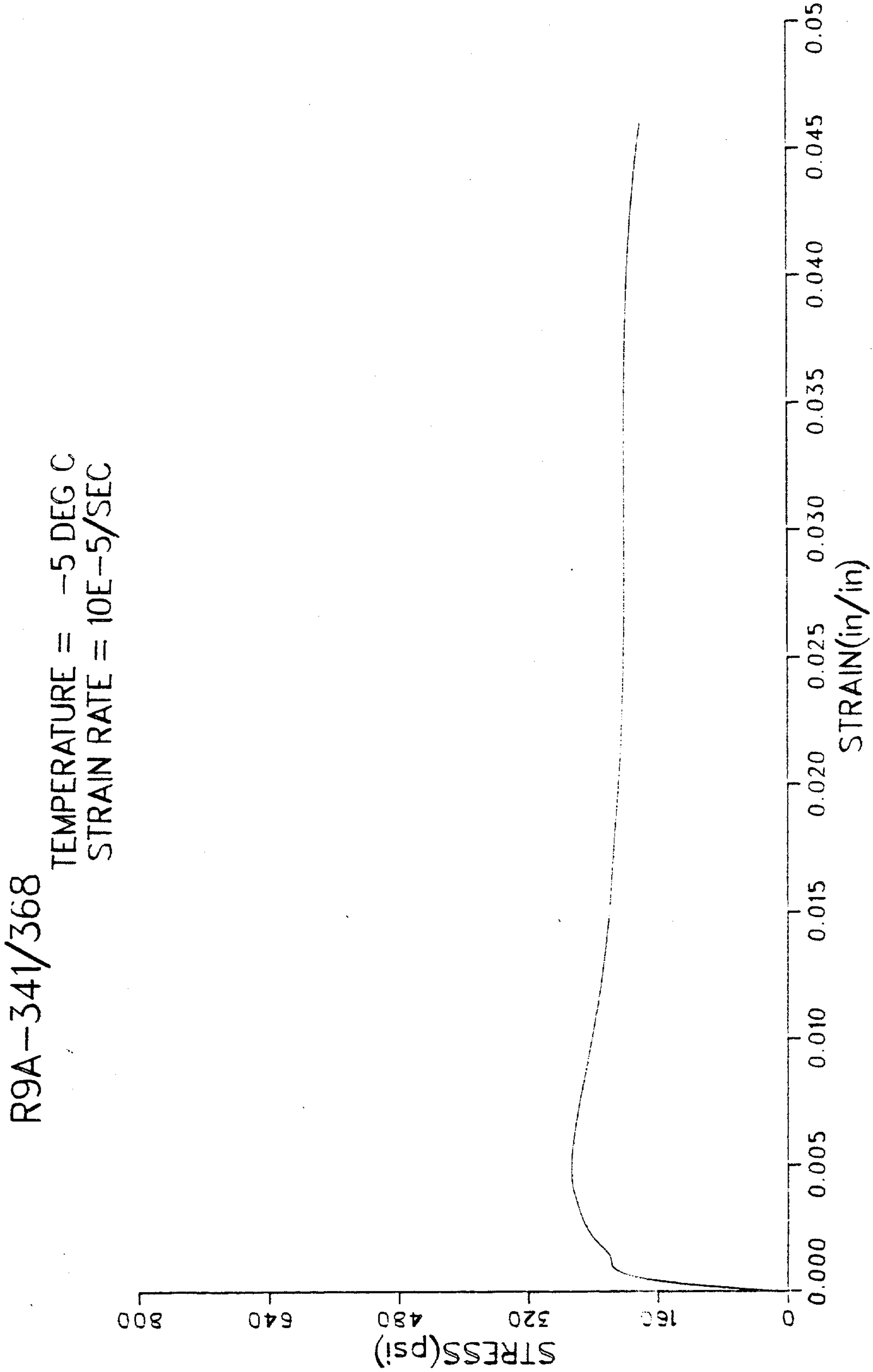

R6C-529/556
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

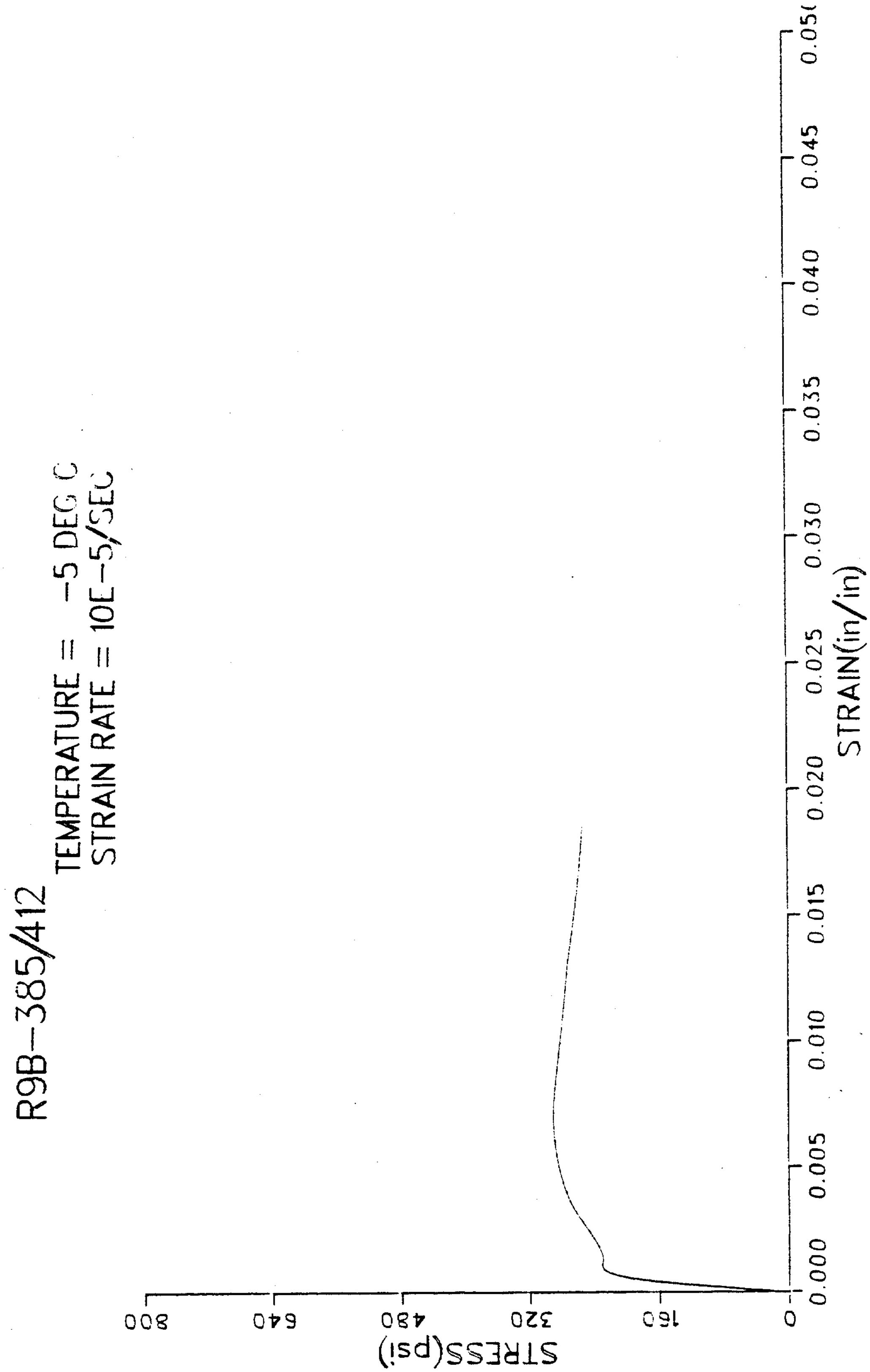

R8C-378/405
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

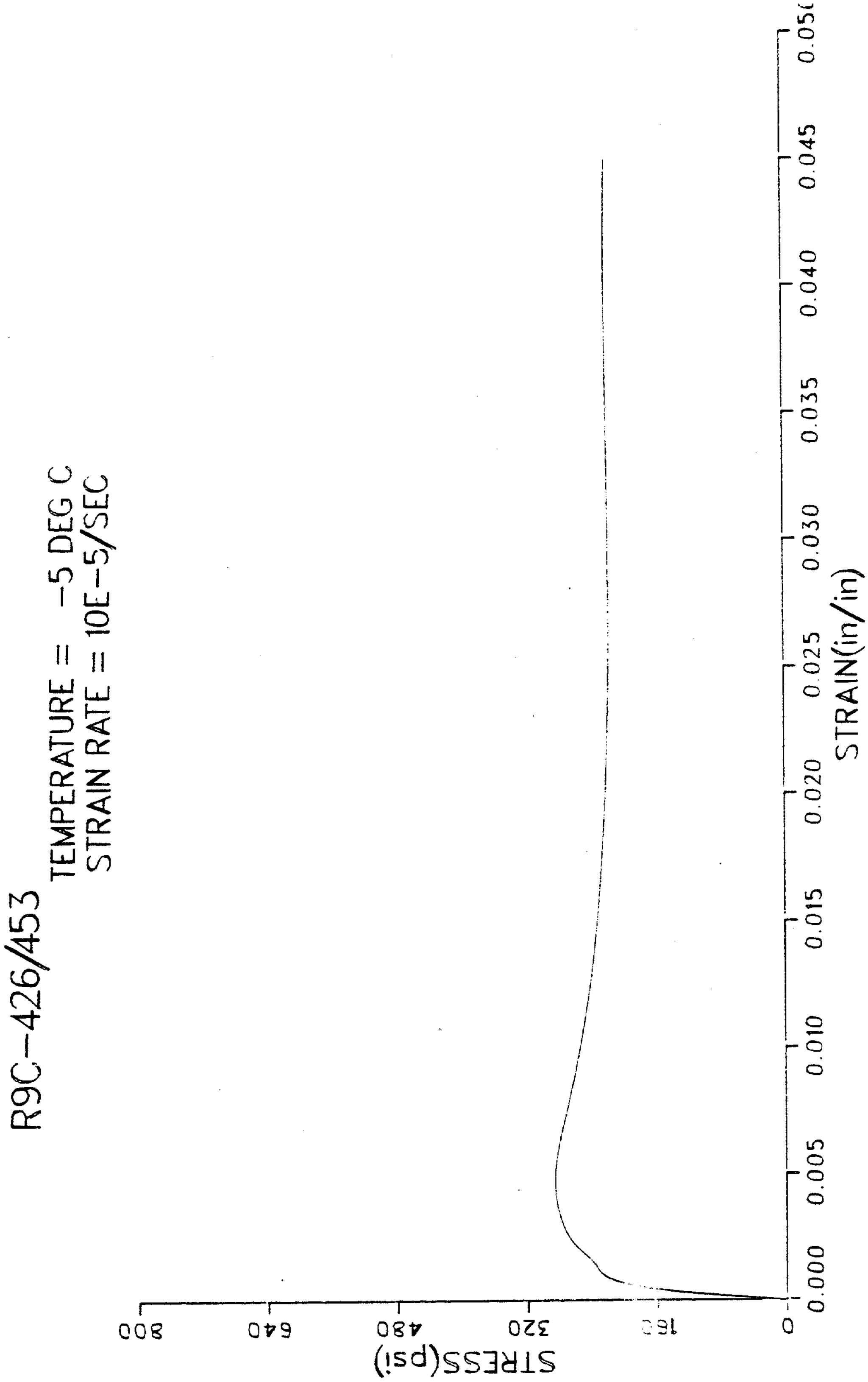

R8C-476/503
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.05

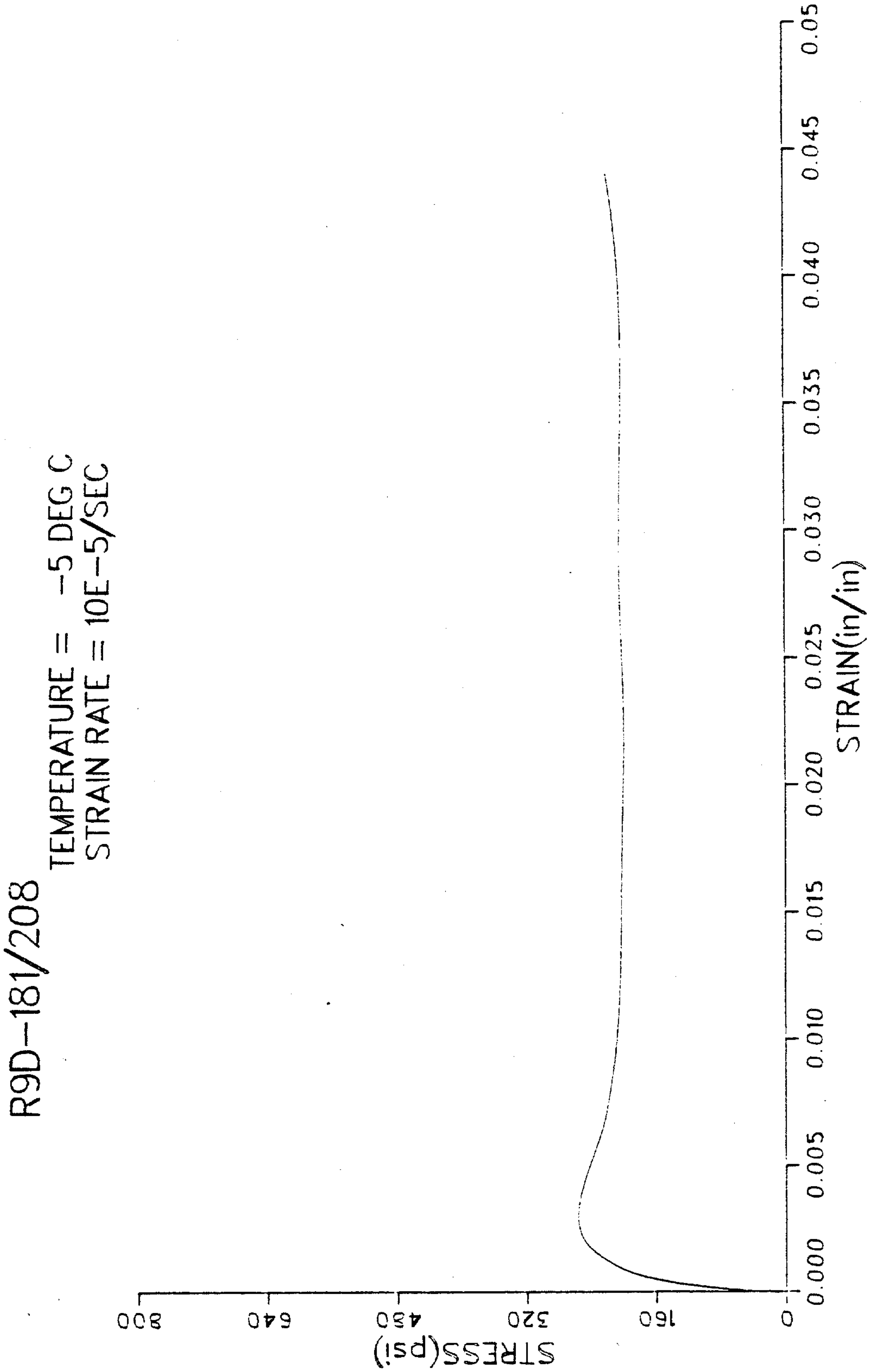

R8D-446/473
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.05

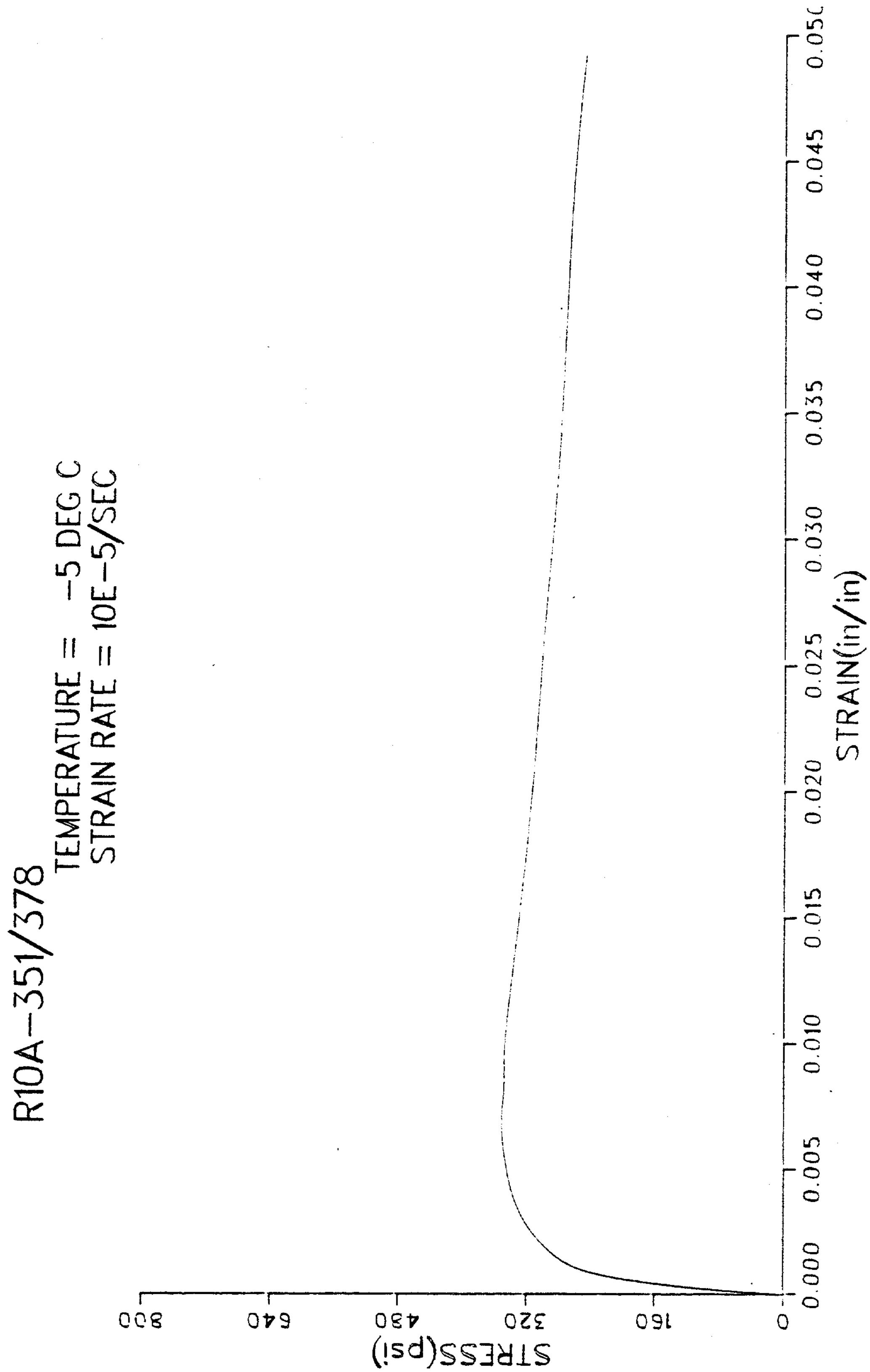

R8D-534/561
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.05

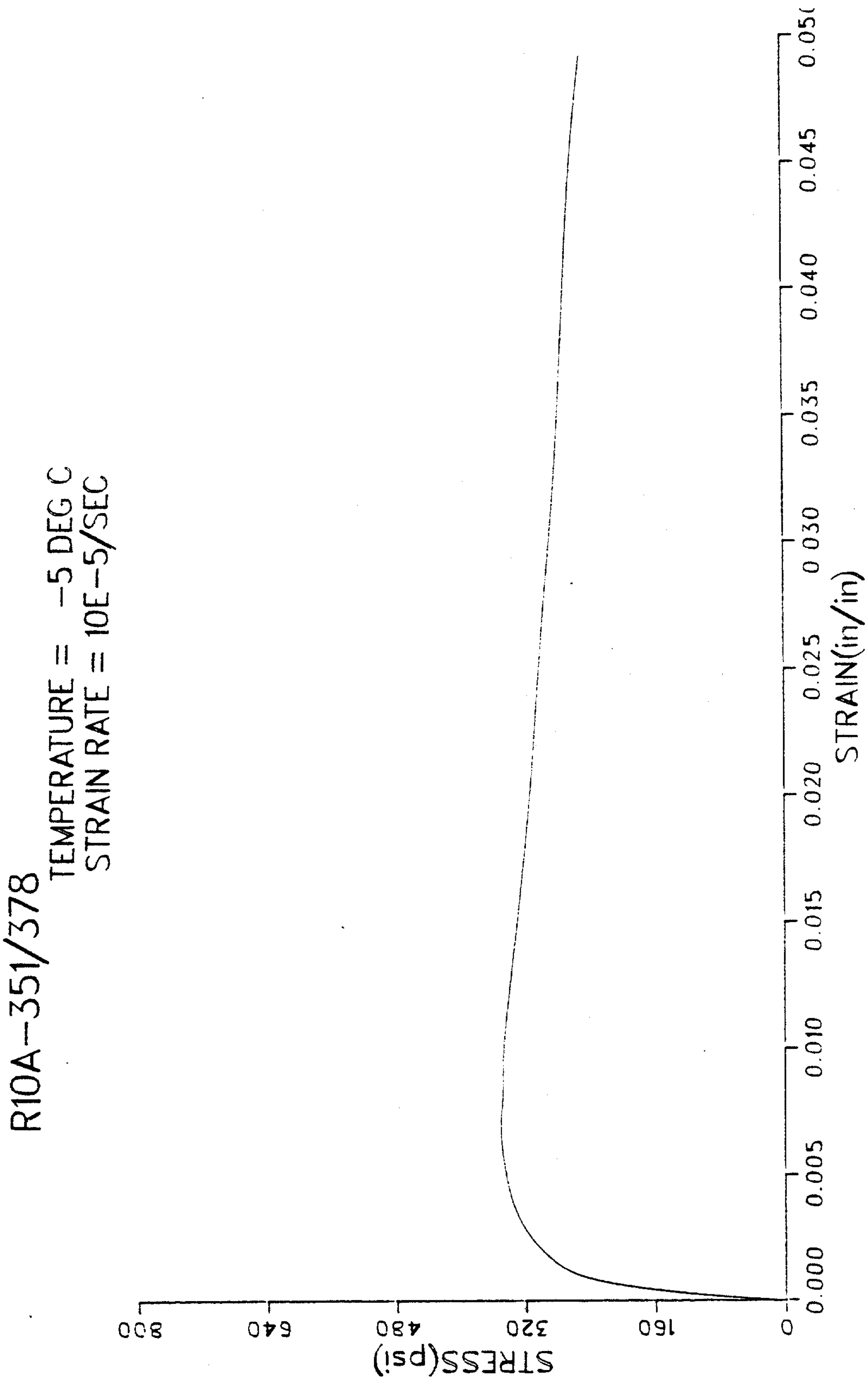

R9A-341/368
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

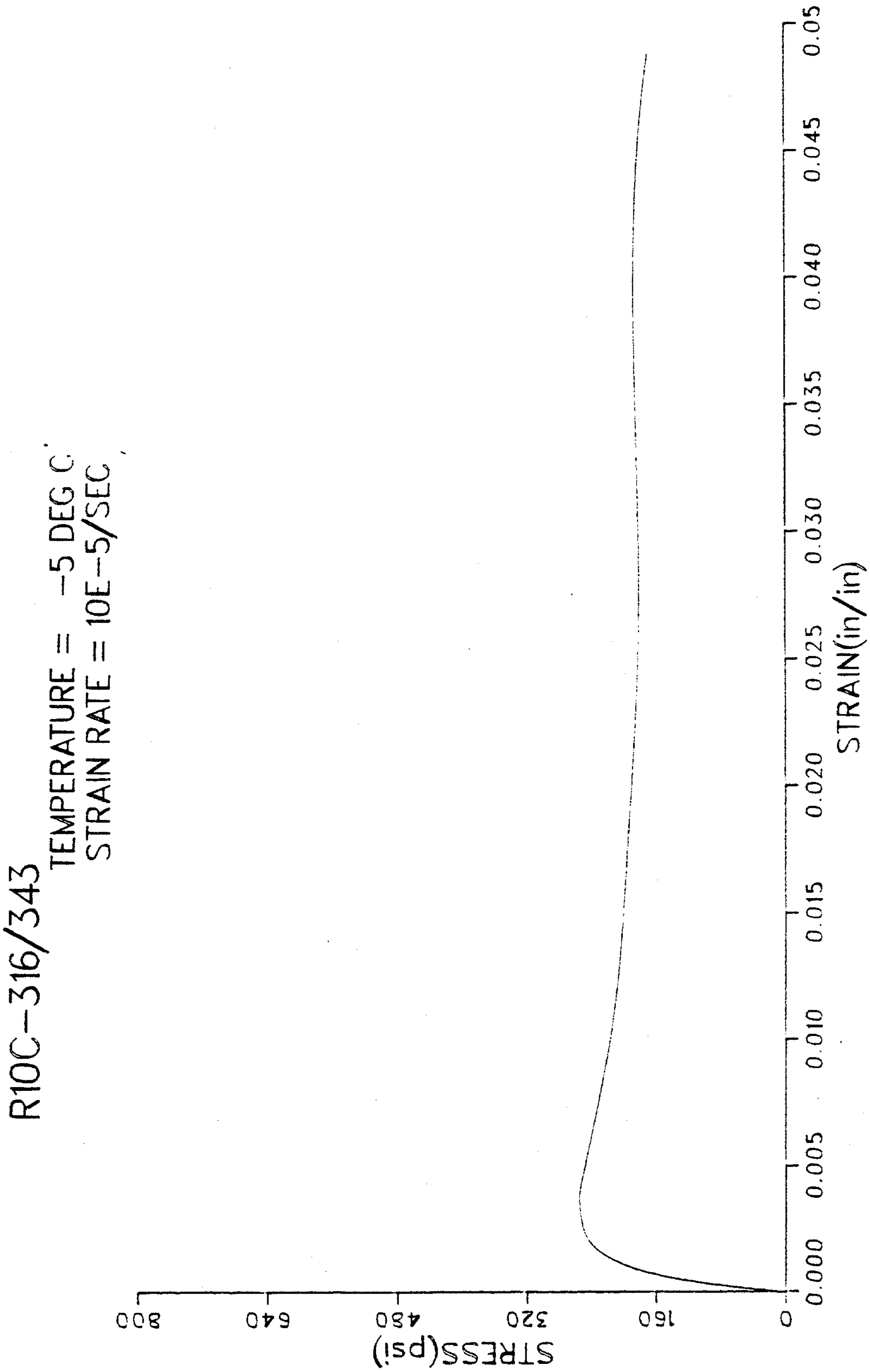

R9B-385/412
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

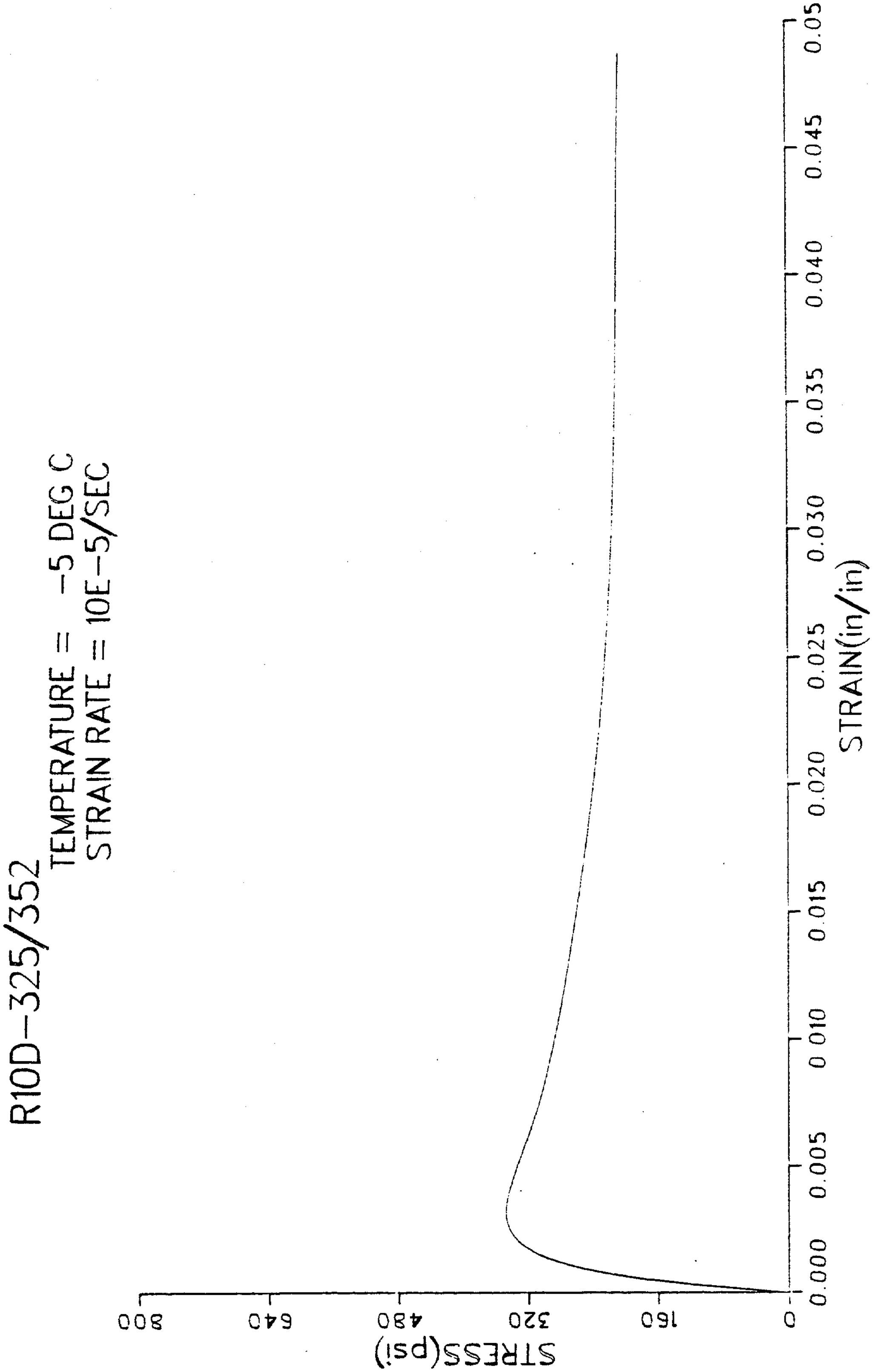

R9C-426/453
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
STRESS(psi)
0
160
320
480
640
800


R9D-181/208
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.05
STRESS(psi)
0
160
320
480
640
800

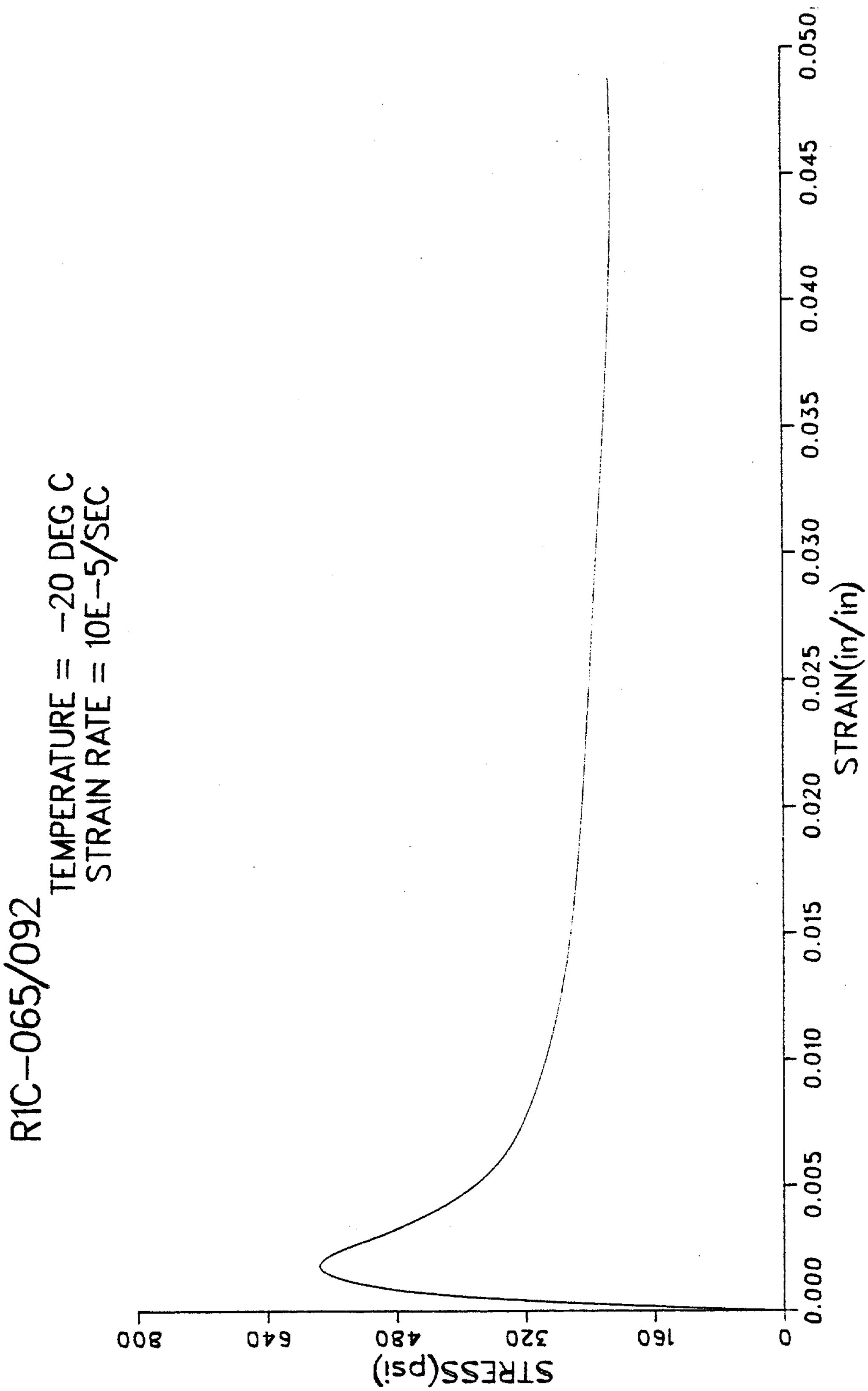

R10A-351/378
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

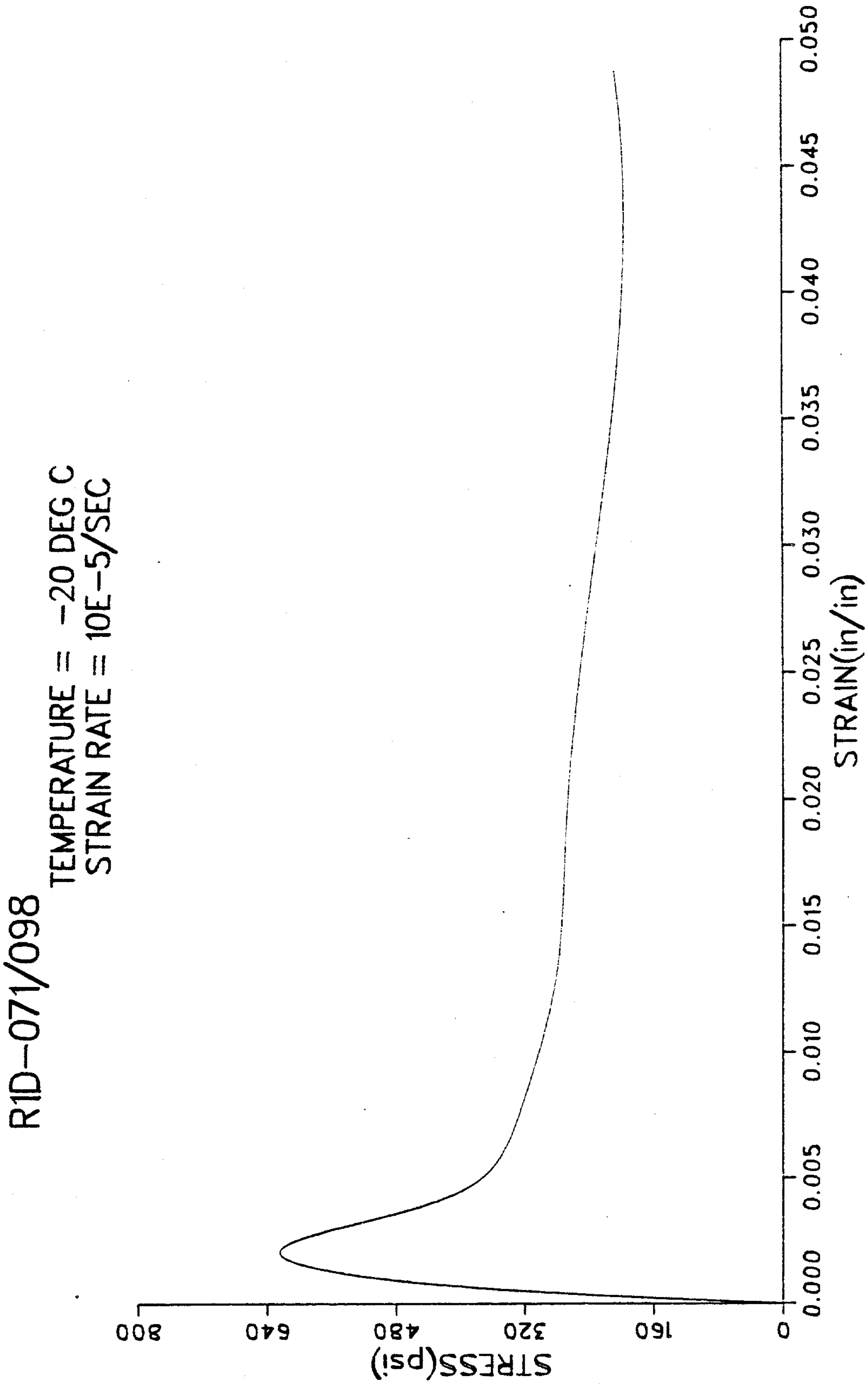

R10A–351/378
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

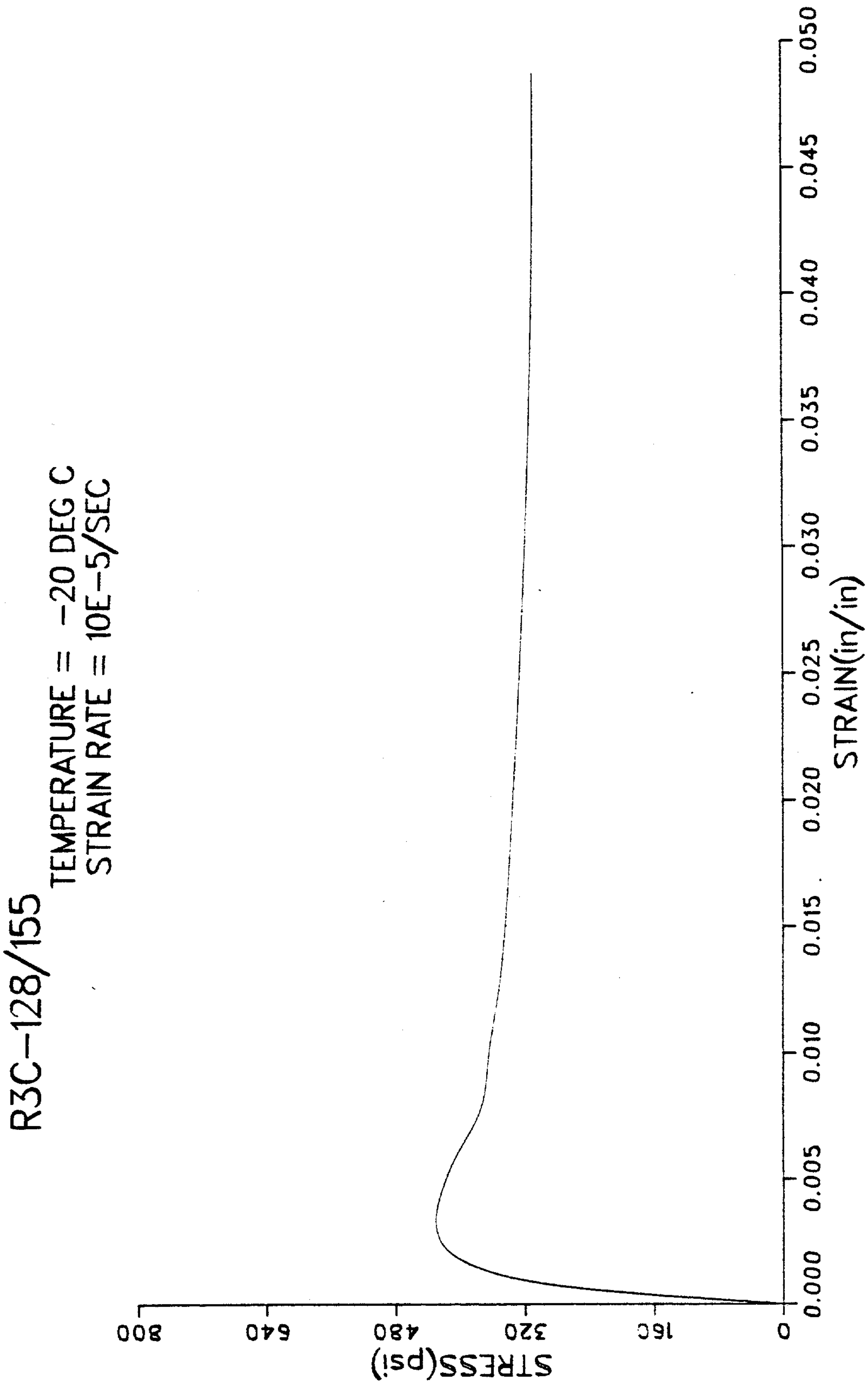

R10C-316/343
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.05
0
160
320
480
640
800

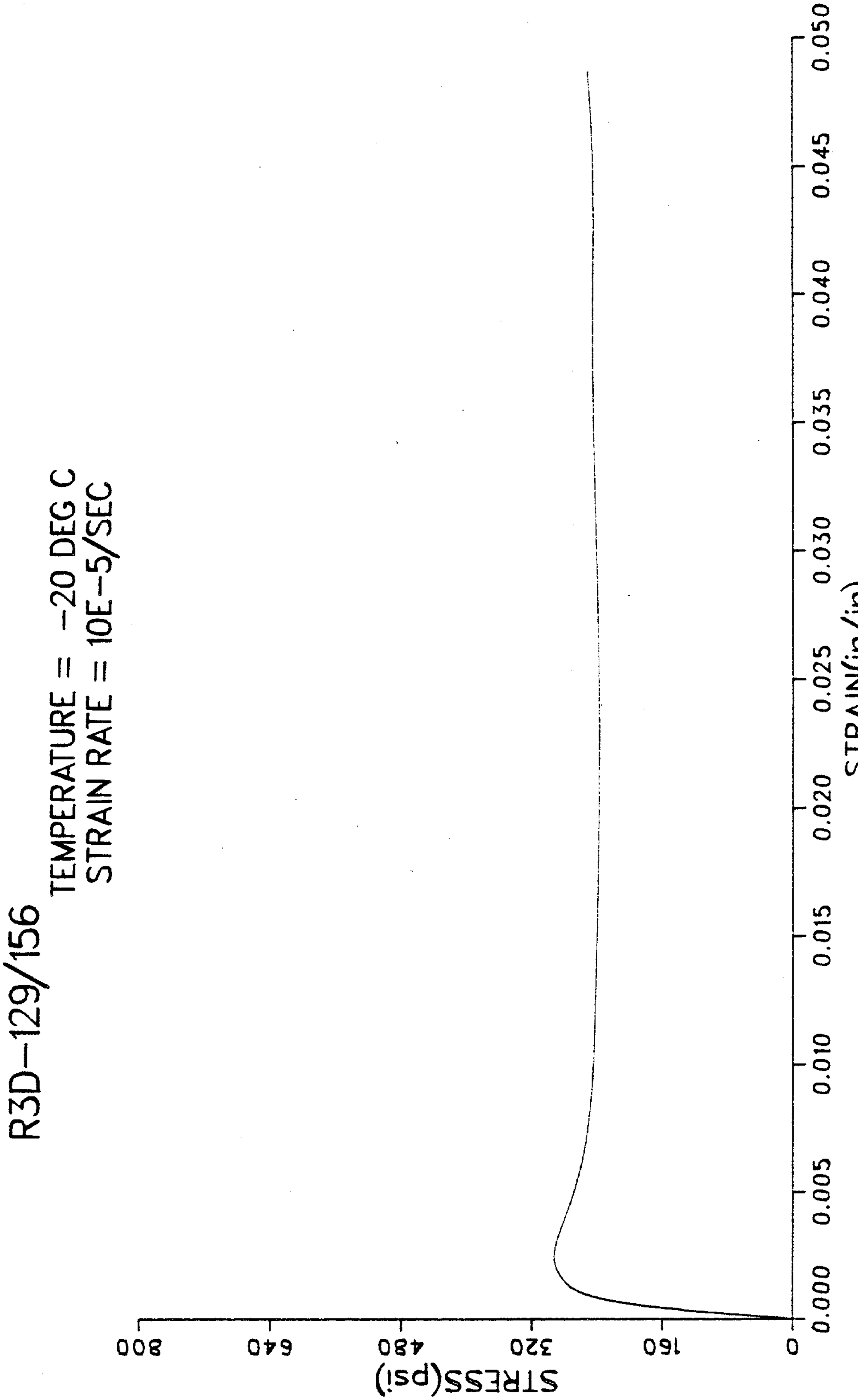

R10D-325/352
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.05

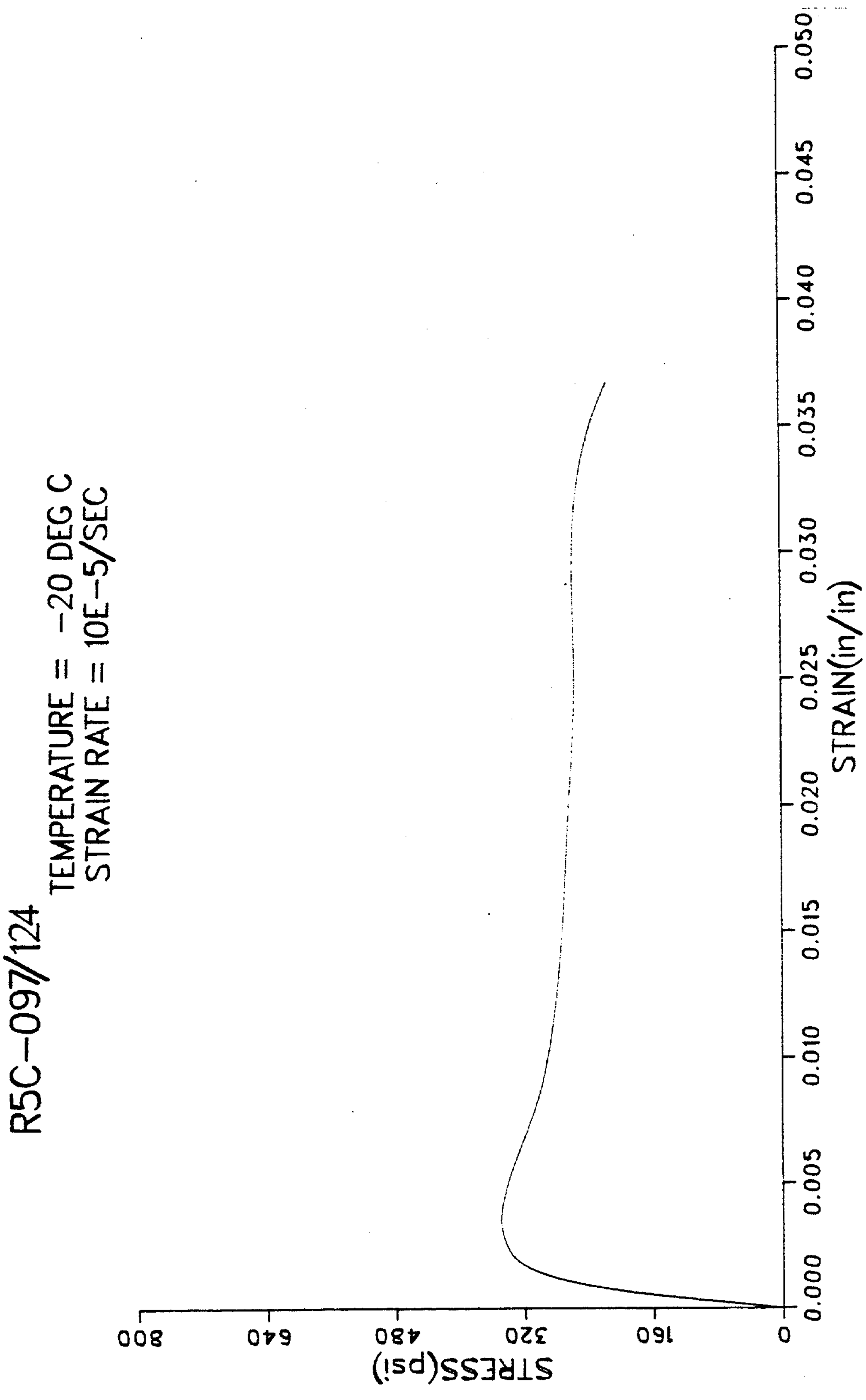
STRAIN RATE = (10E-5)/SEC
TEMPERATURE = -20°C

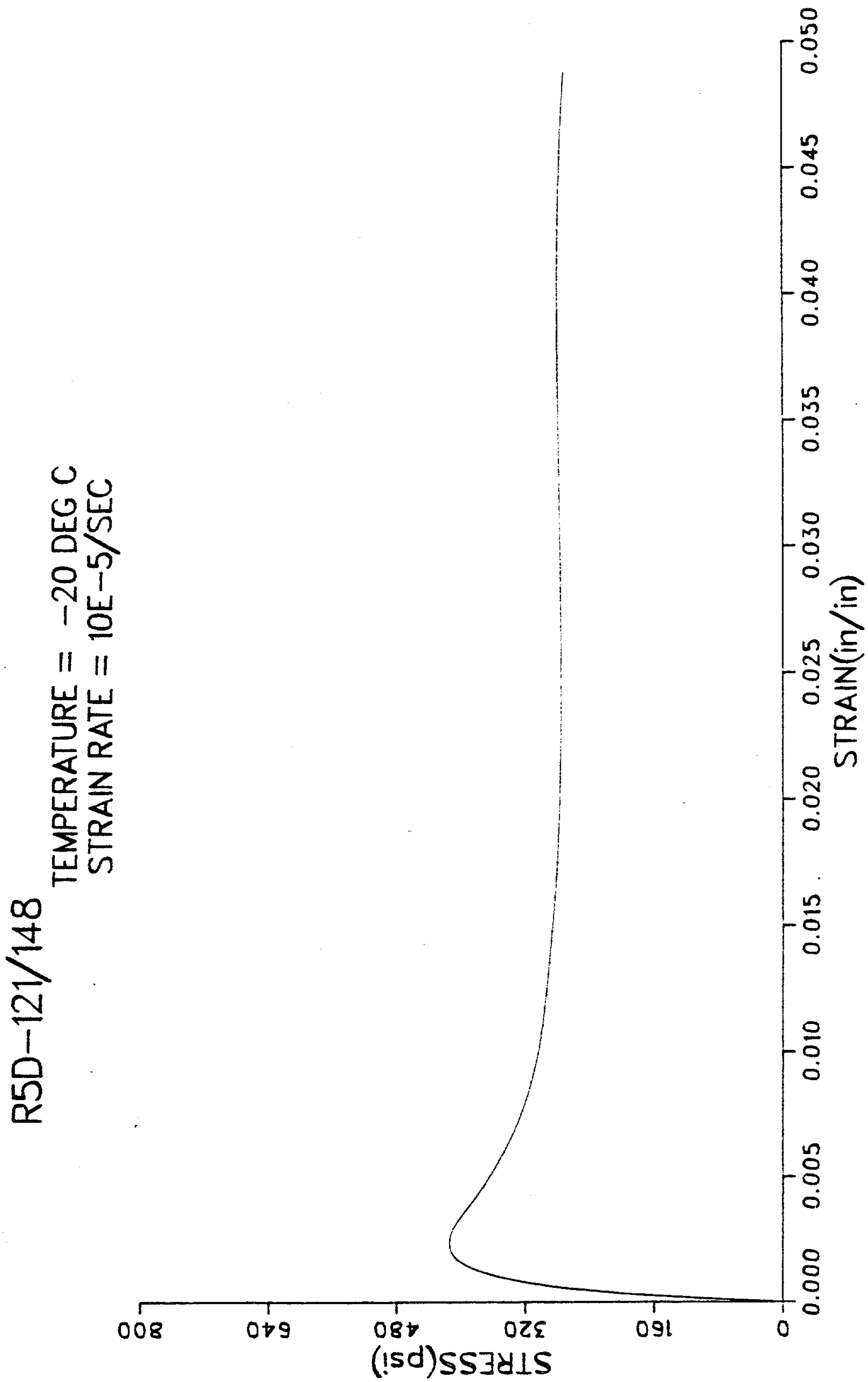

R1C-065/092
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

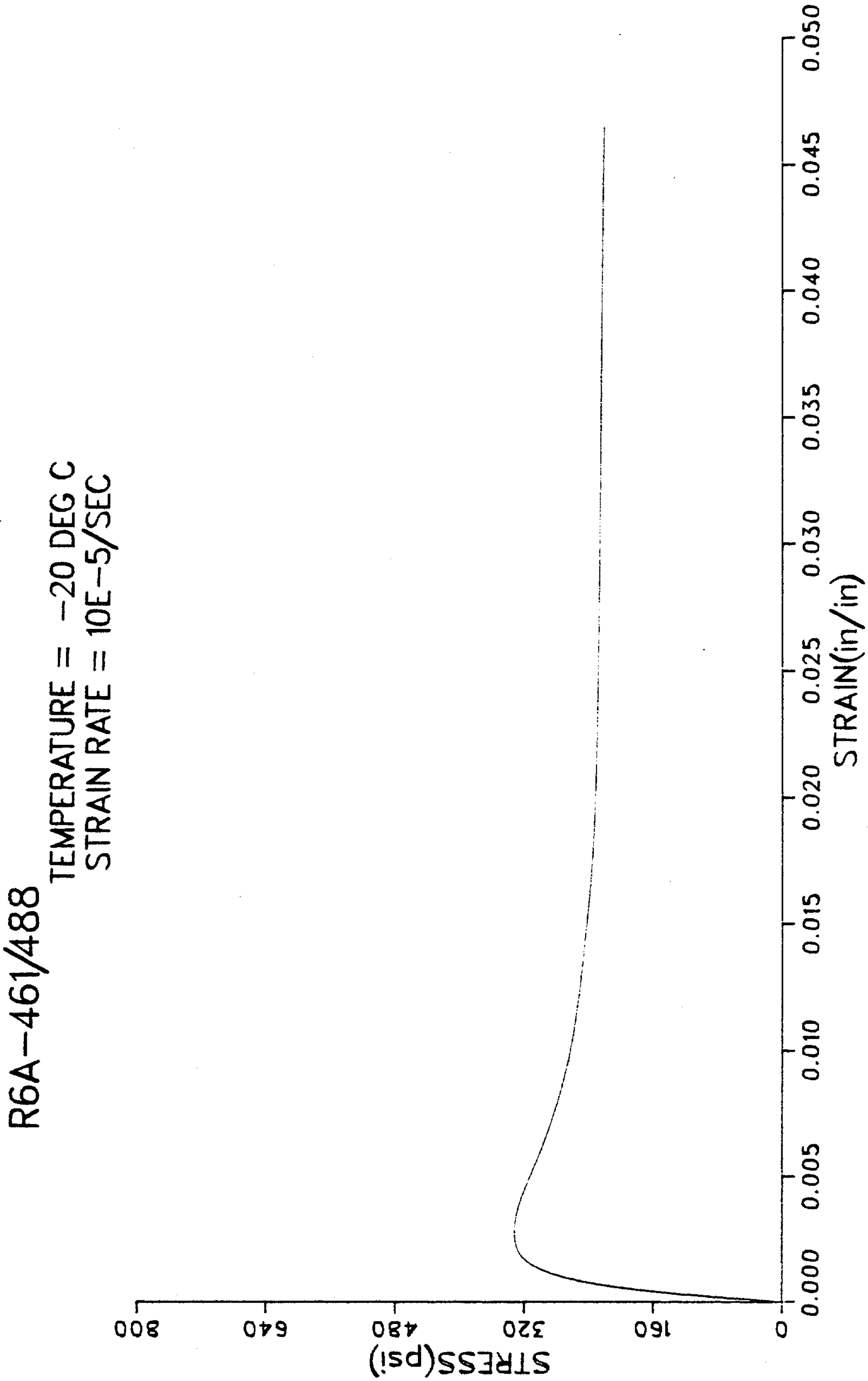

R1D-071/098
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

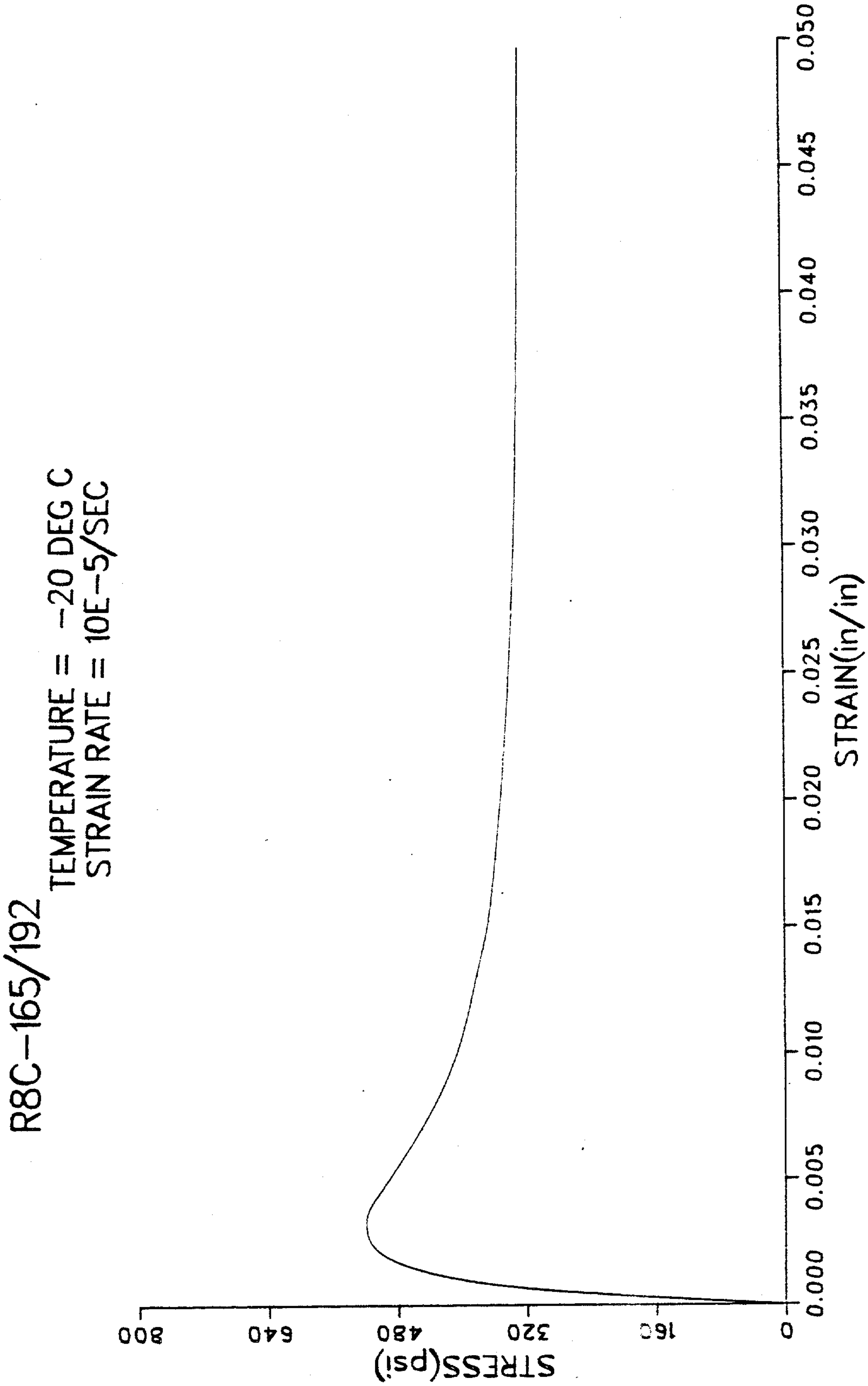

R3C-128/155
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

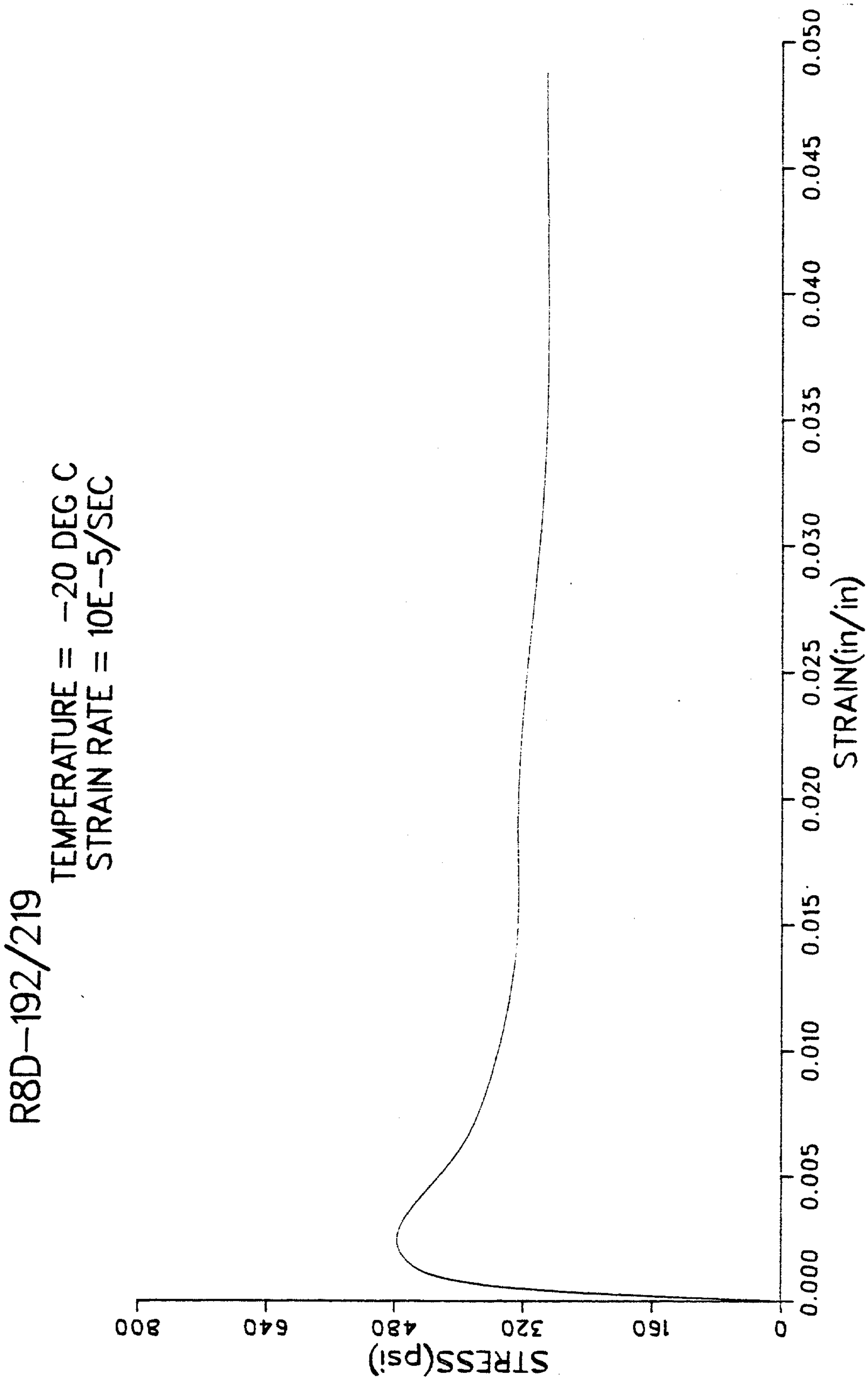

R3D-129/156
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
160
320
480
640
800

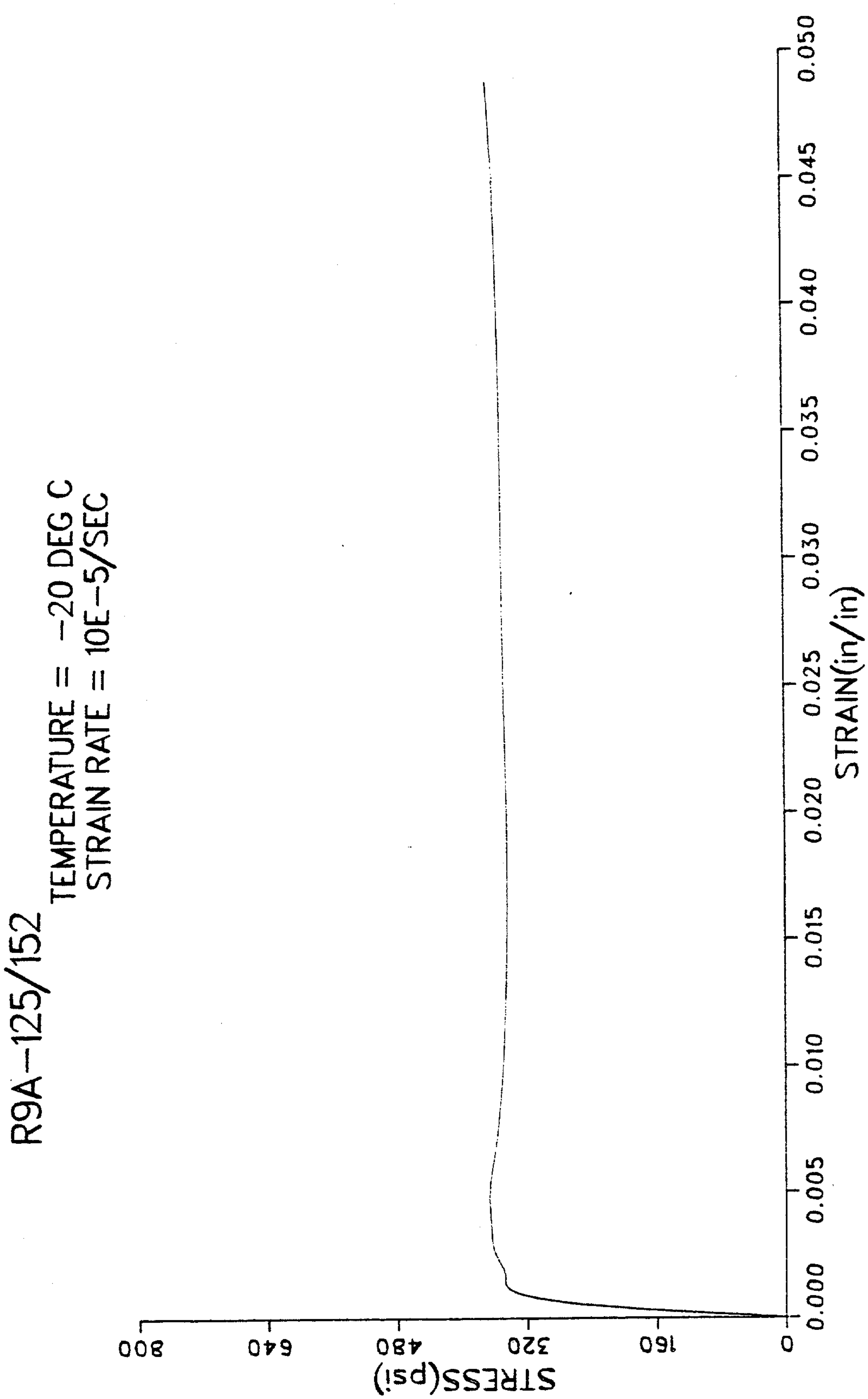

R5C-097/124
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

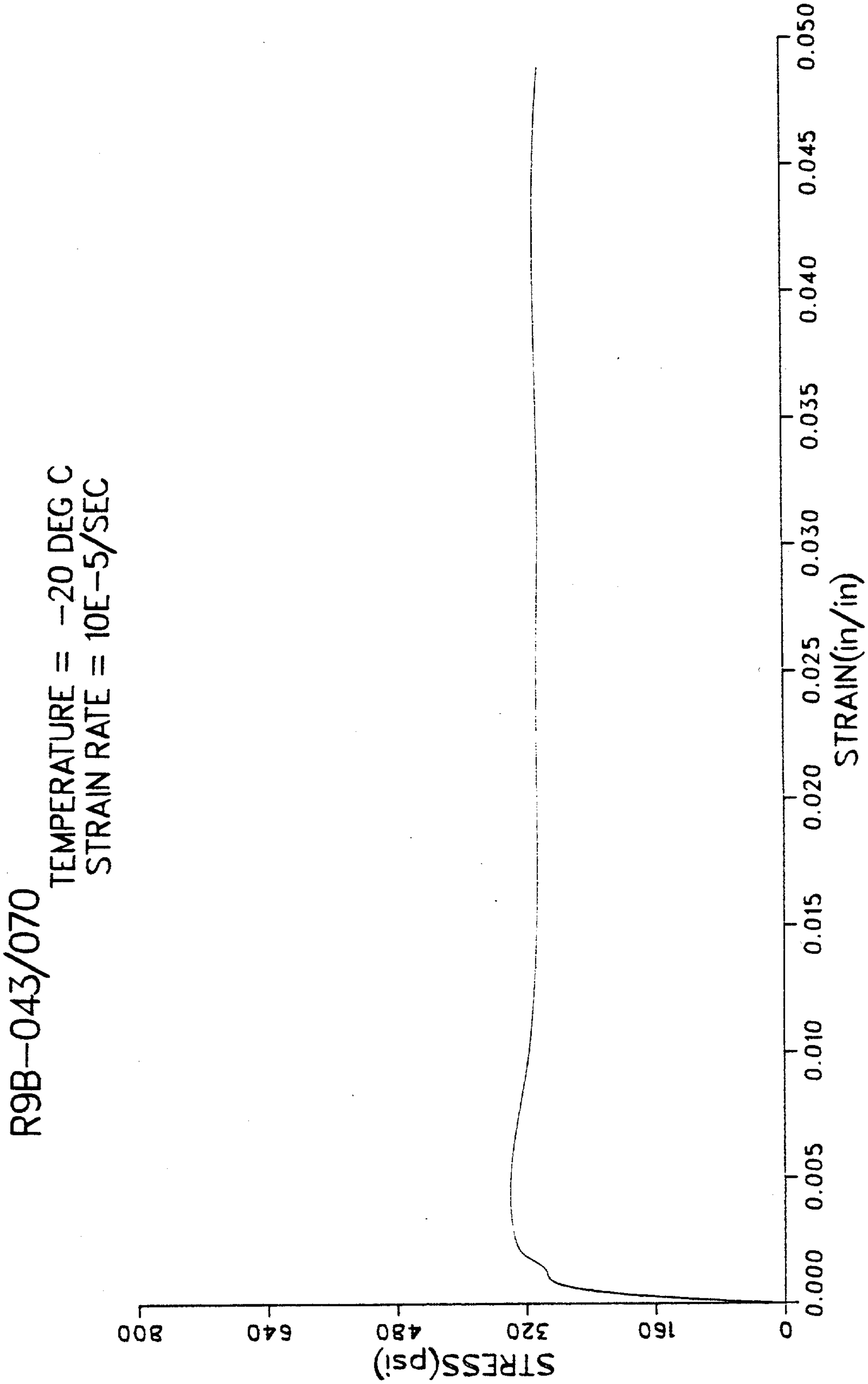

R5D-121/148
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

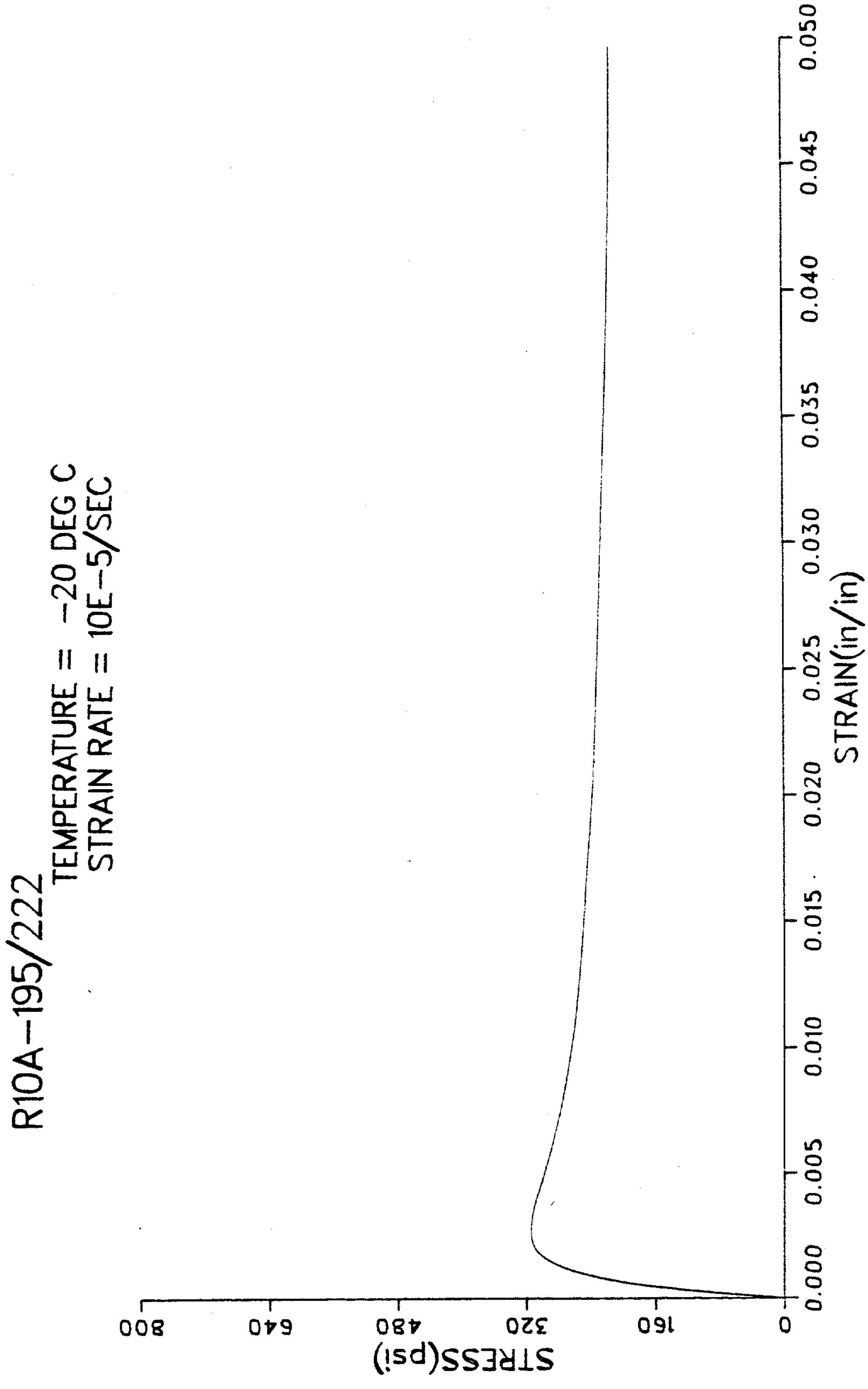

R6A-461/488
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
160
320
480
640
800

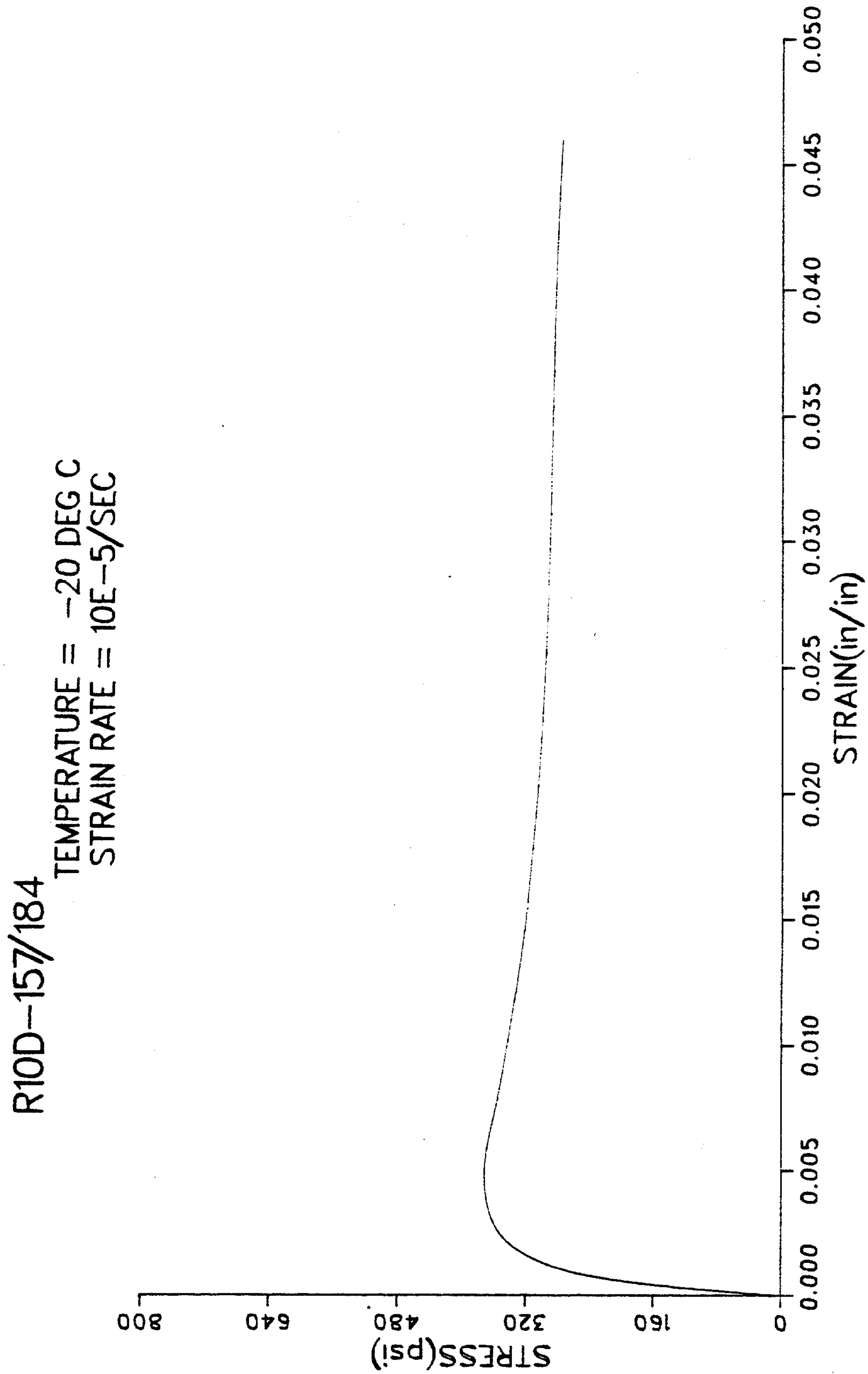

R8C–165/192
TEMPERATURE = –20 DEG C
STRAIN RATE = 10E–5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

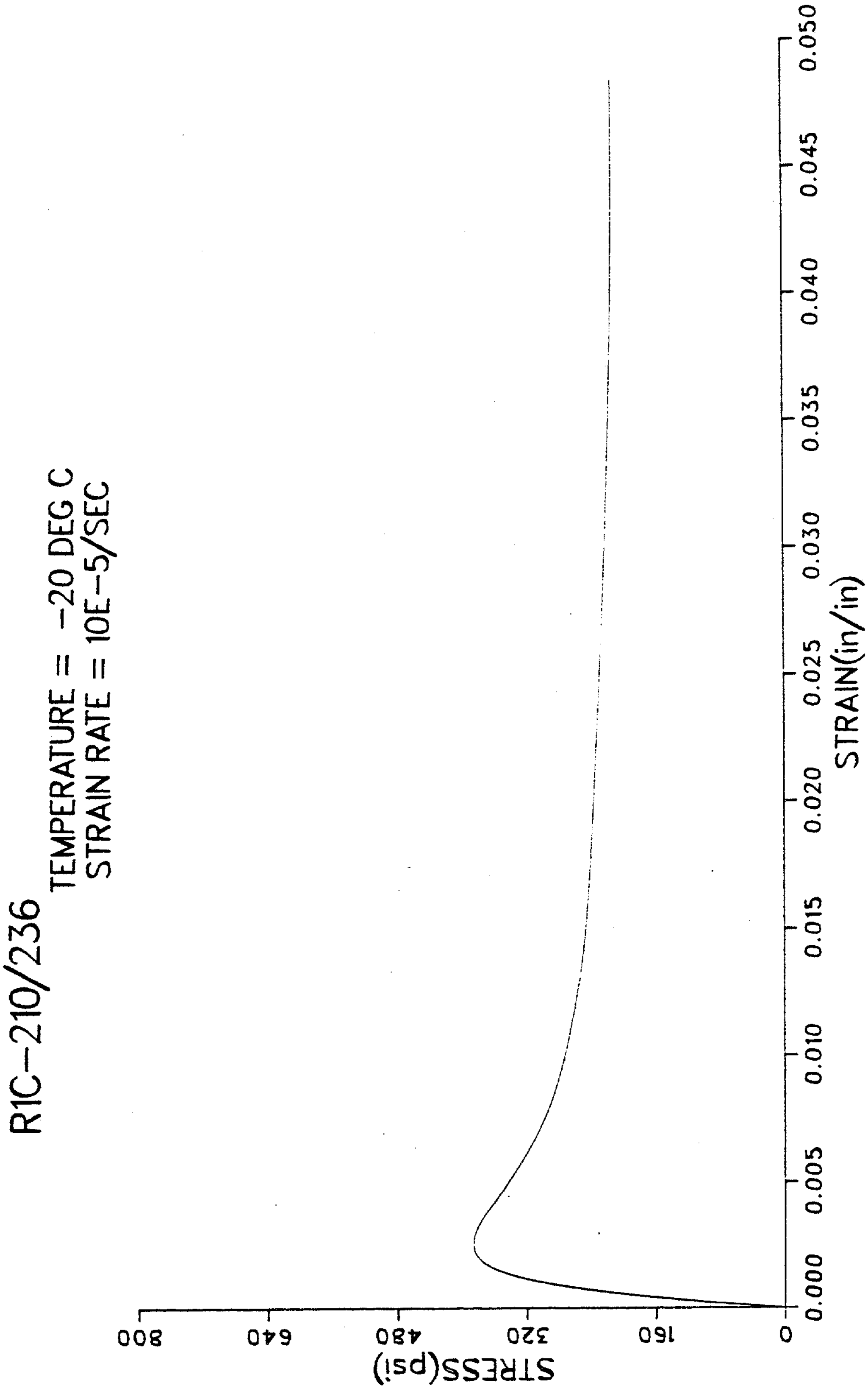

R8D-192/219
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

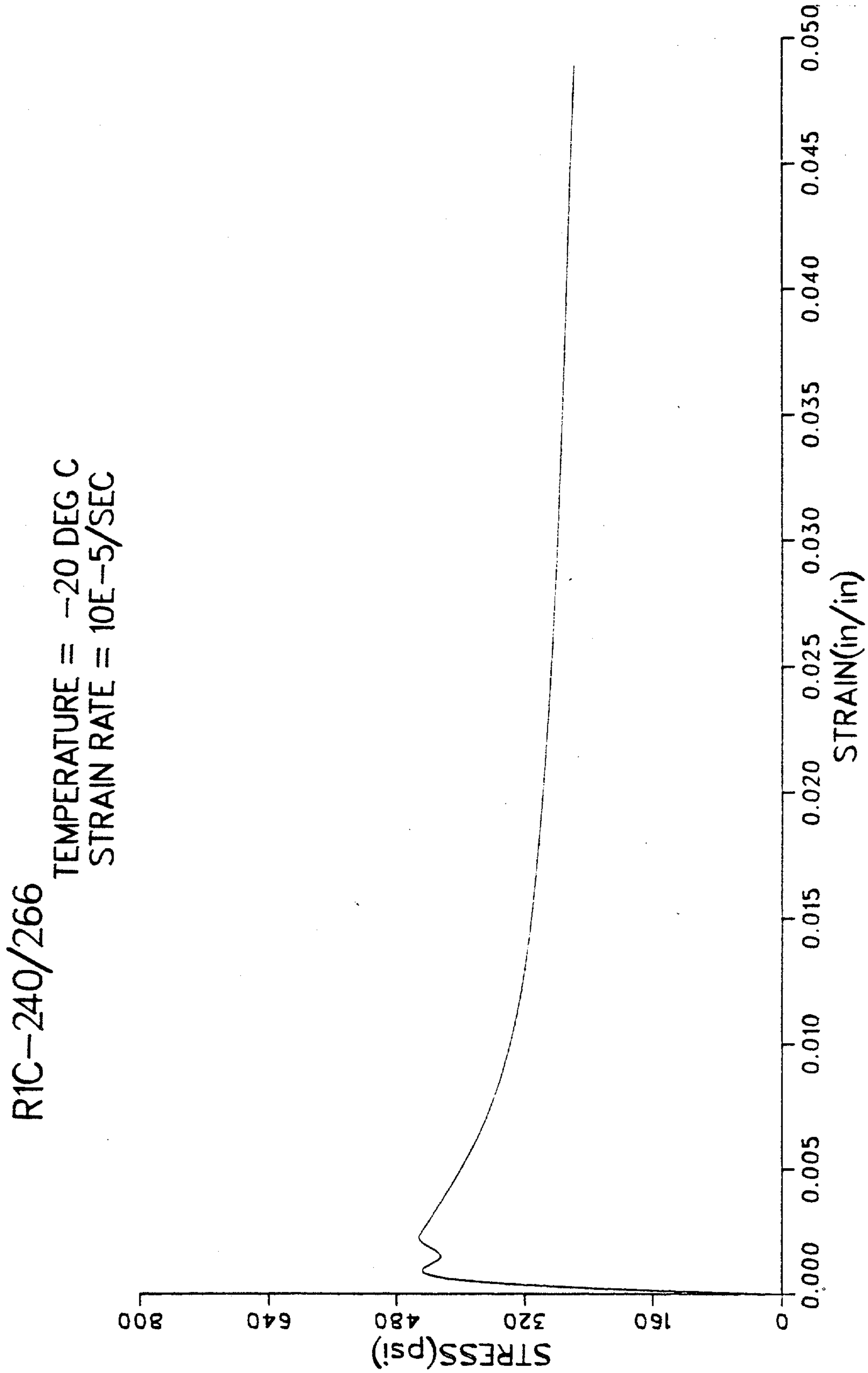

R9A-125/152
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

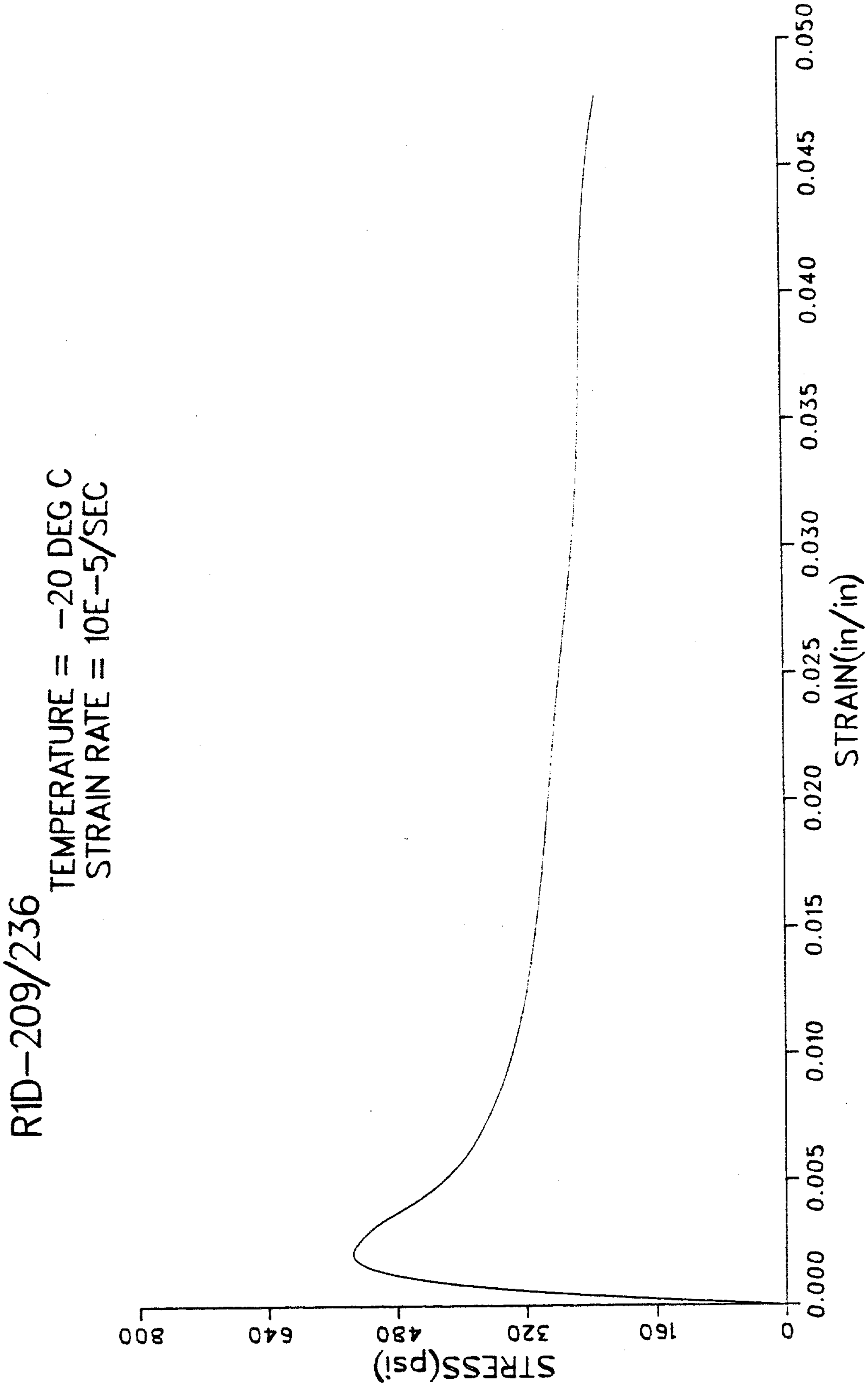

R9B-043/070
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
160
320
480
640
800

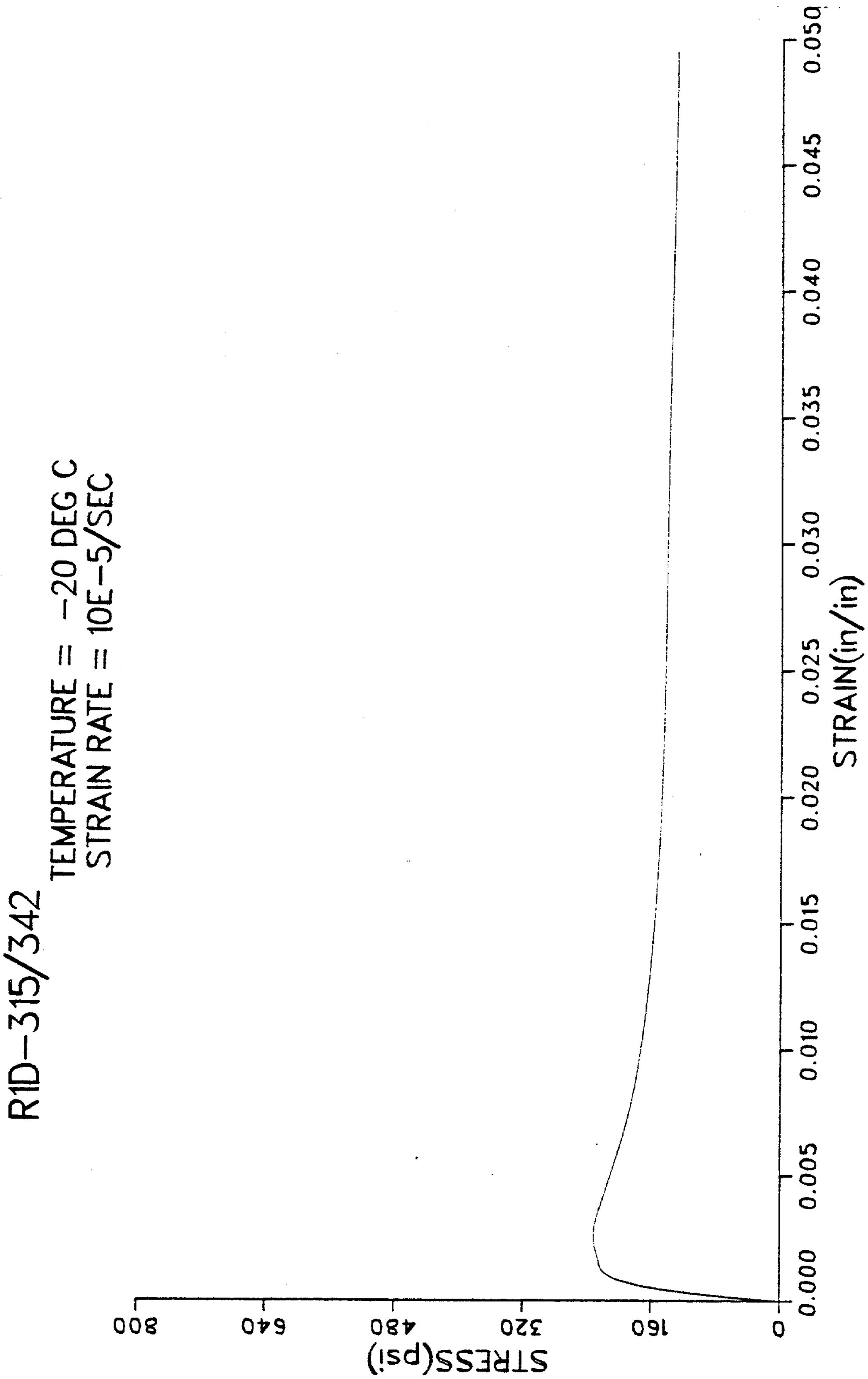

R10A-195/222
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

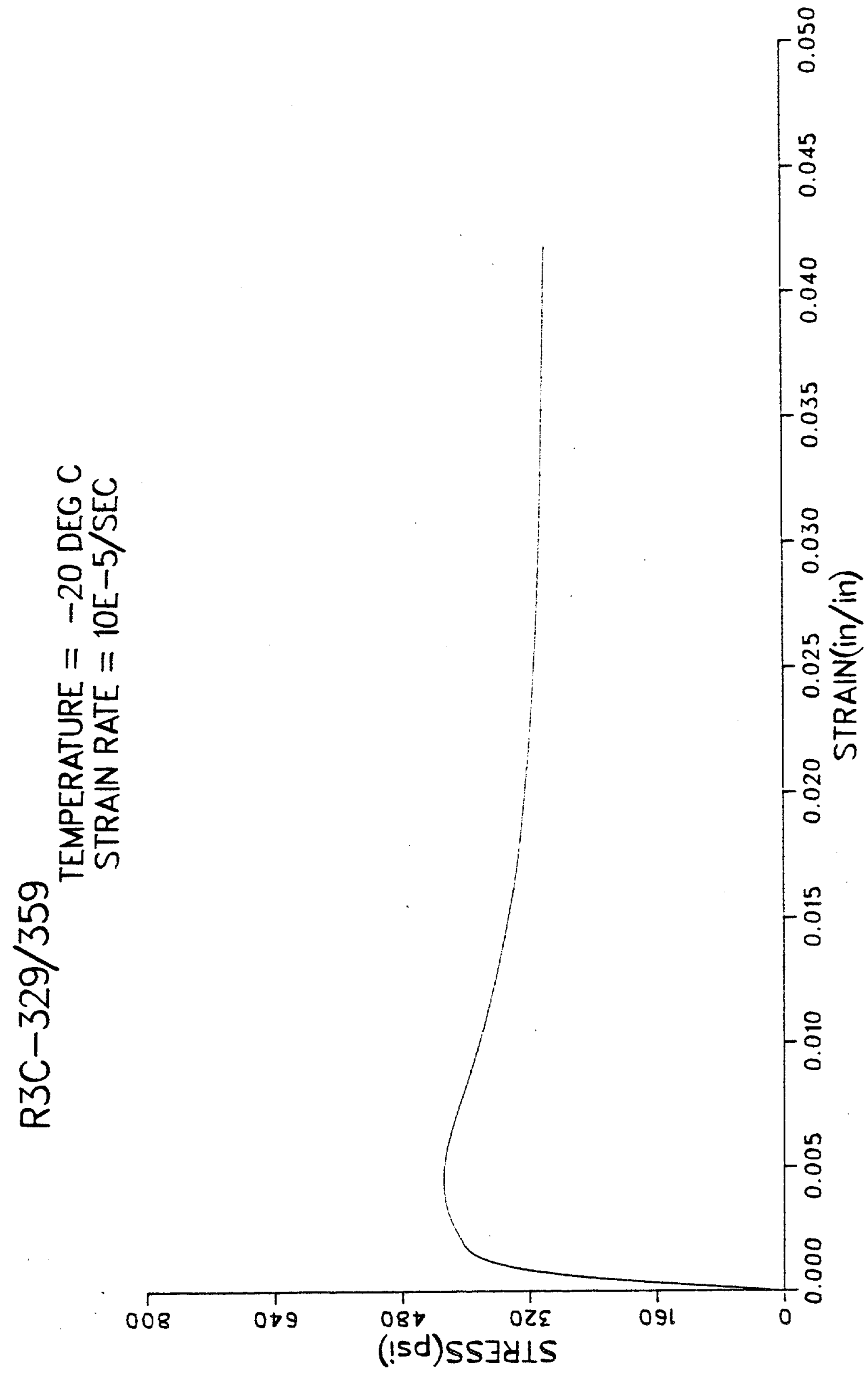

R10D—157/184
TEMPERATURE = −20 DEG C
STRAIN RATE = 10E−5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

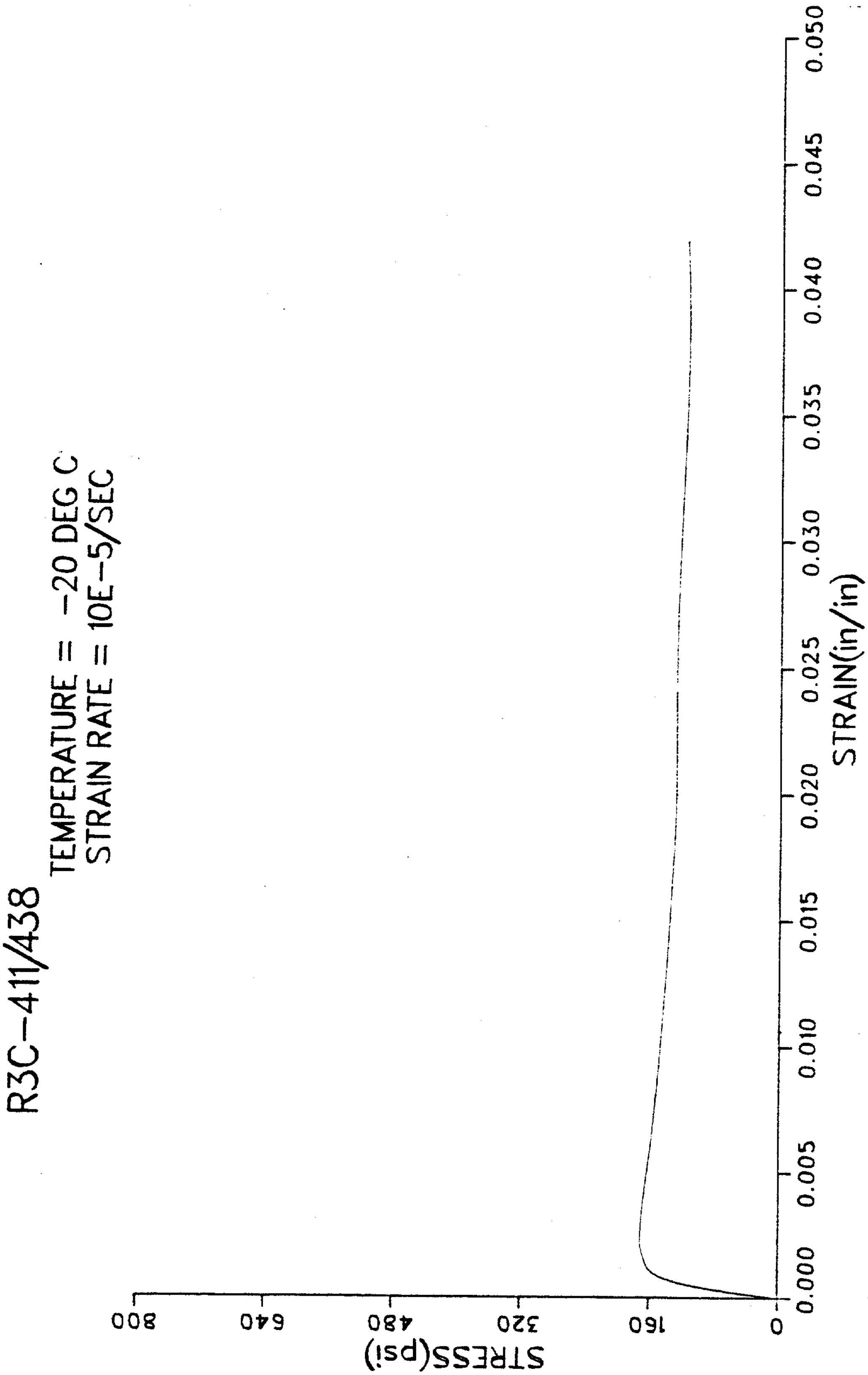

R1C–210/236
TEMPERATURE = –20 DEG C
STRAIN RATE = 10E–5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

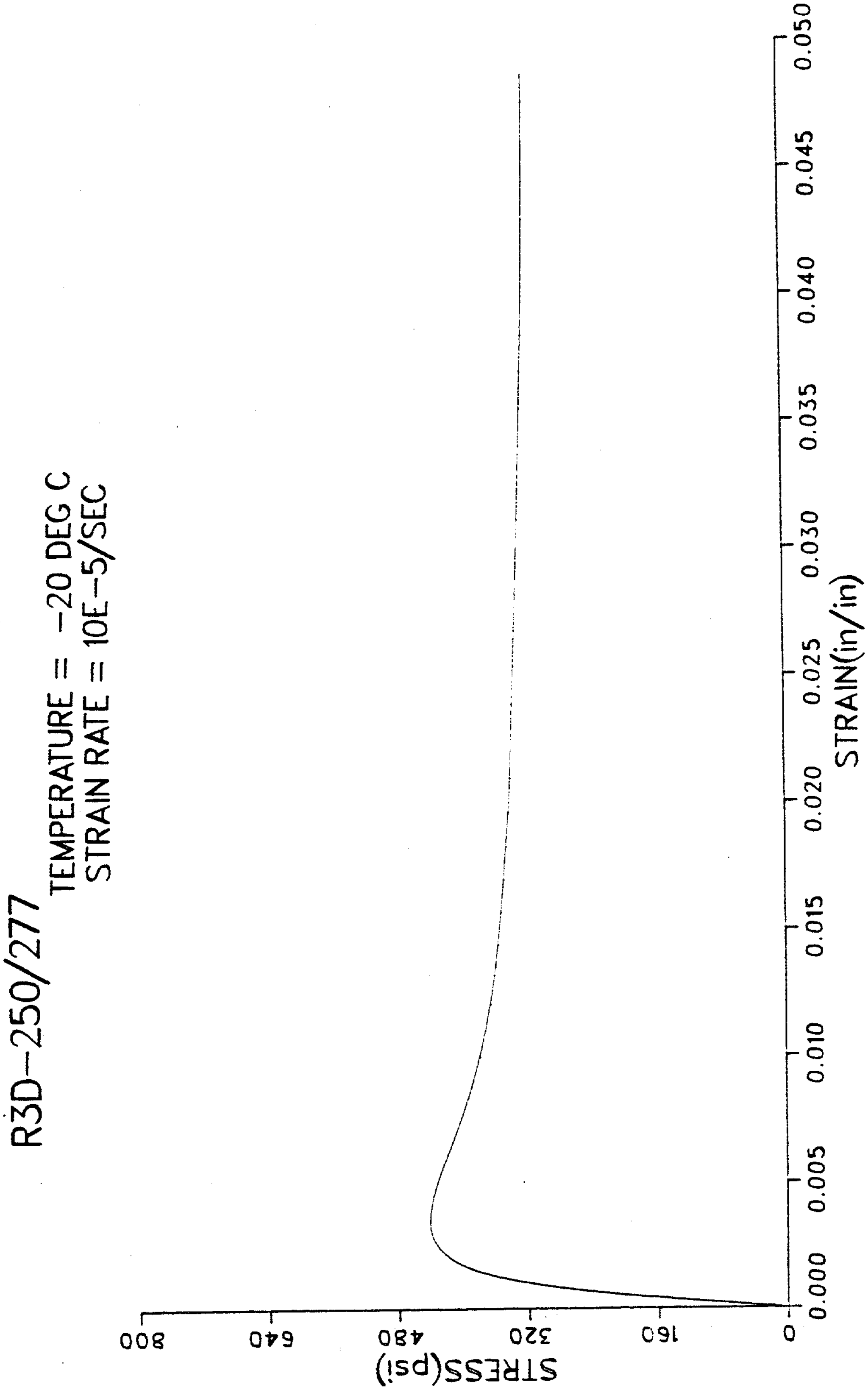

R1C-240/266
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
STRESS(psi)
0
160
320
480
640
800
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

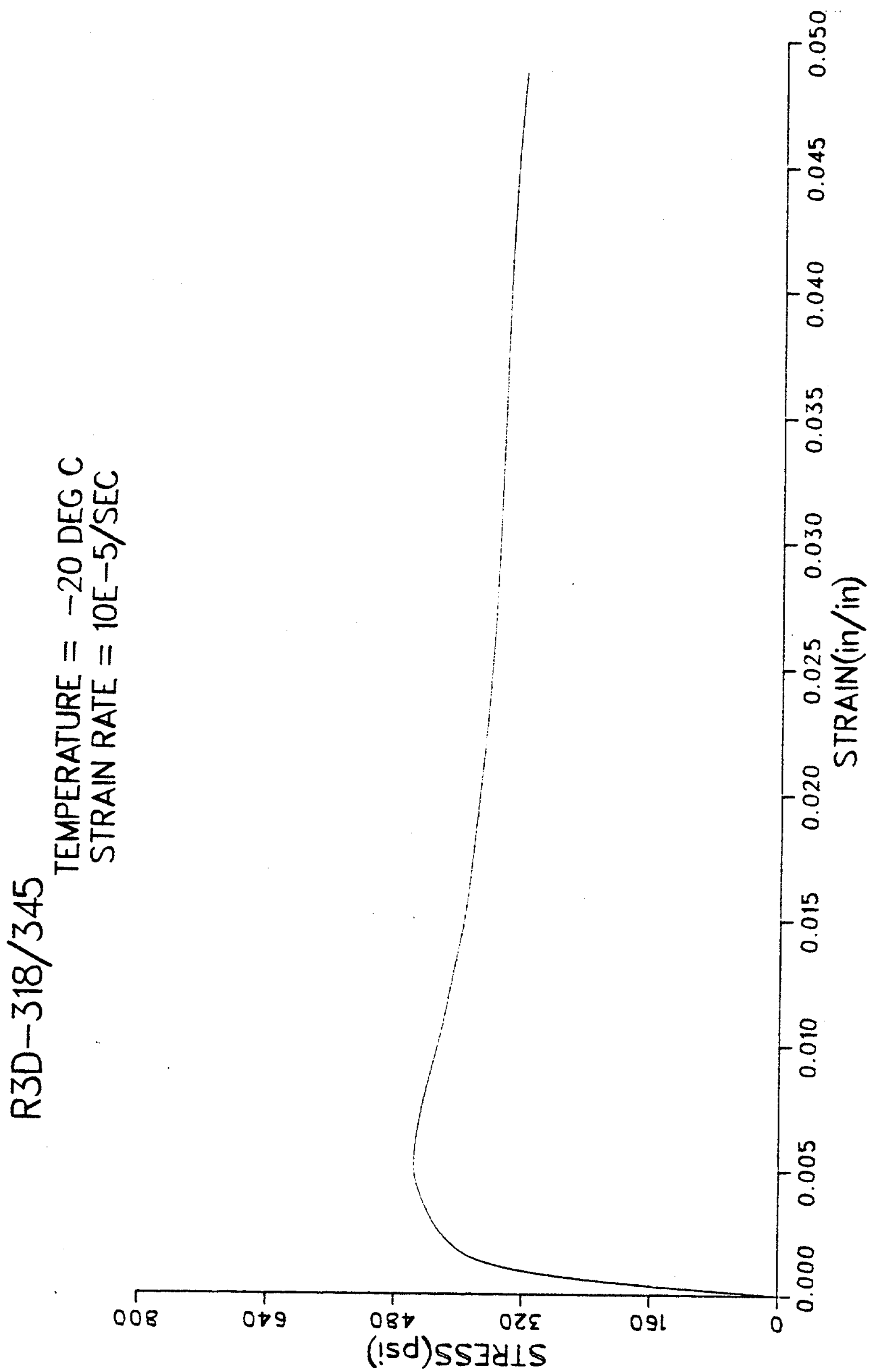

R1D-209/236
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
160
320
480
640
800

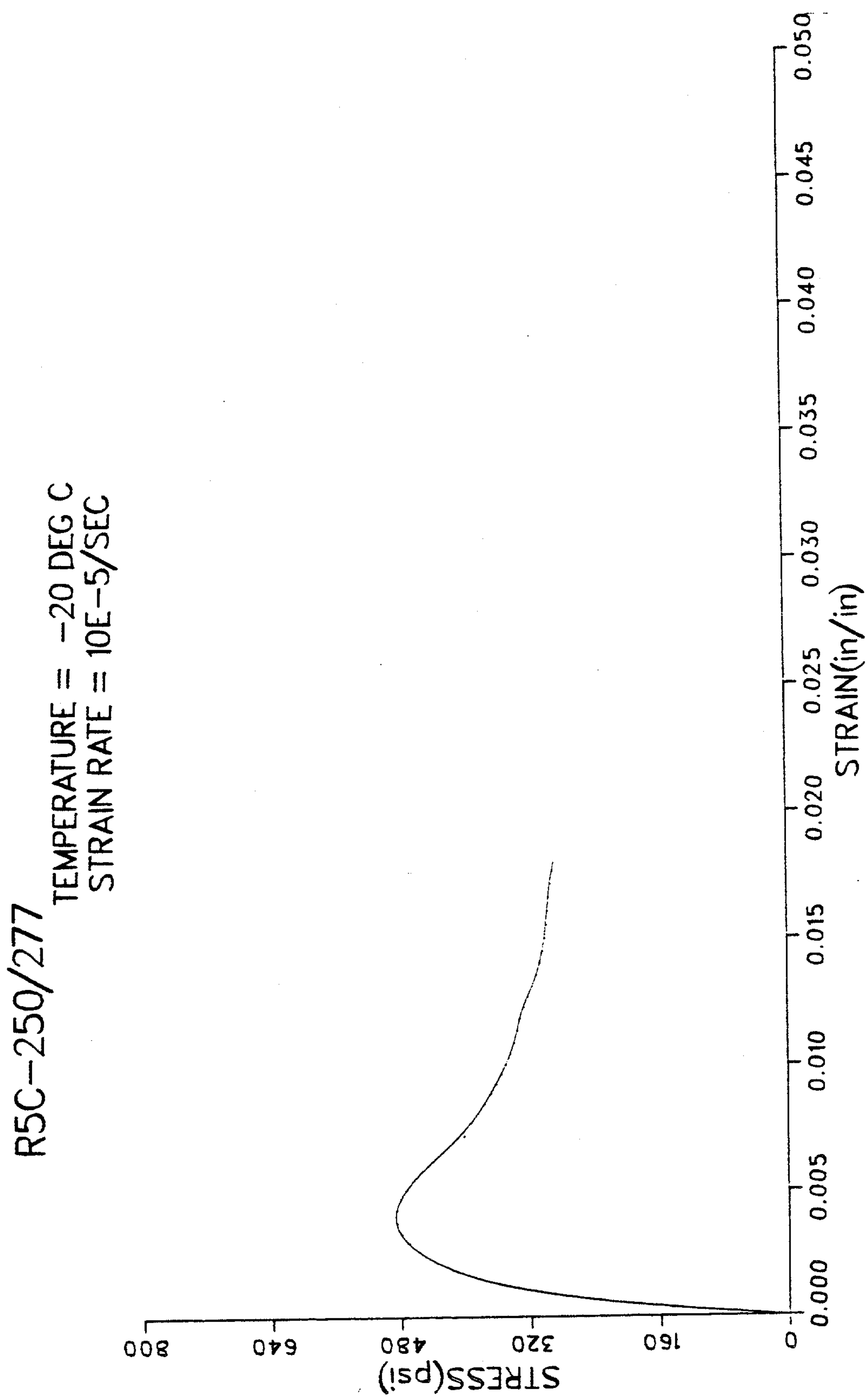

R1D-315/342
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

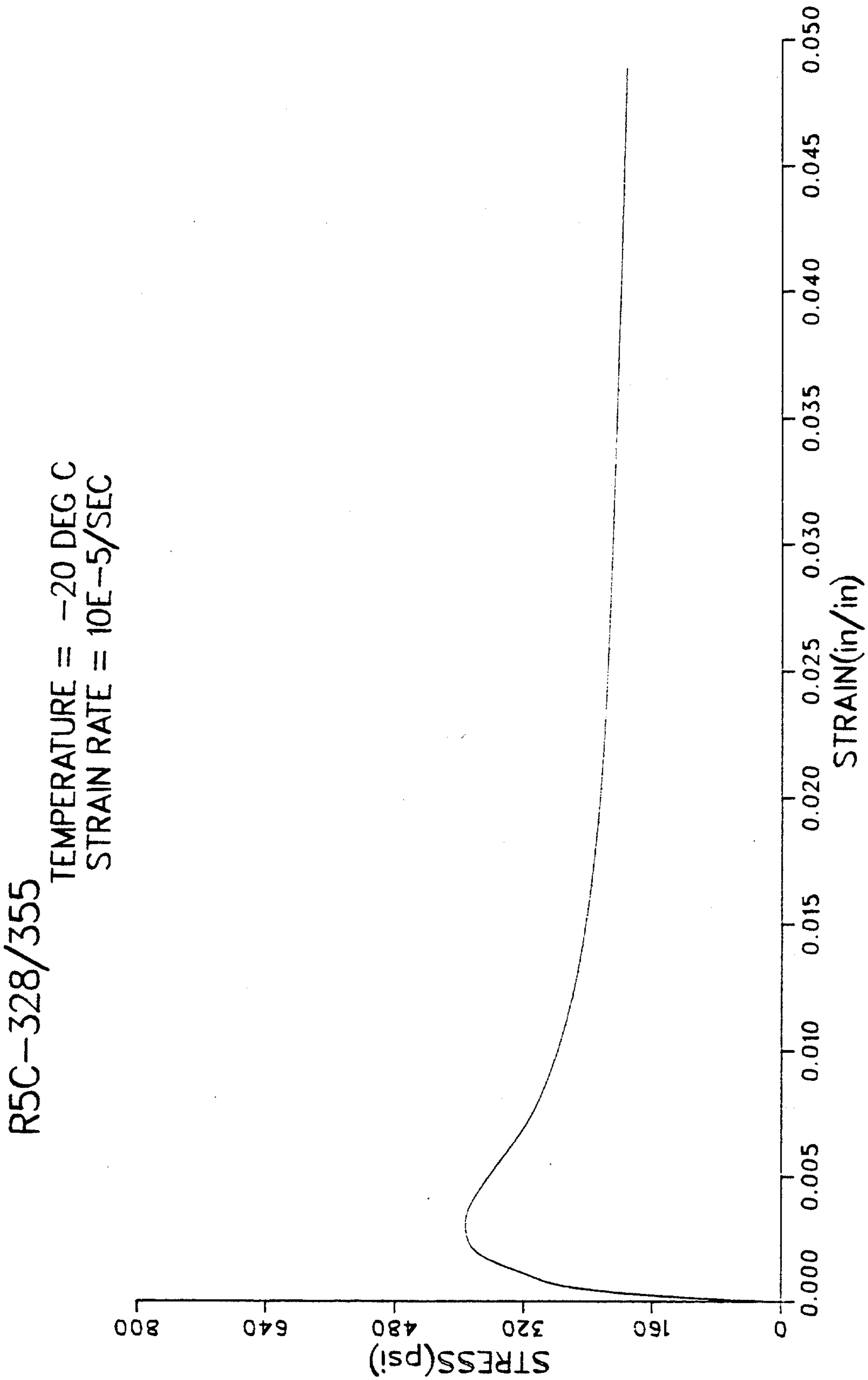

R3C-329/359
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

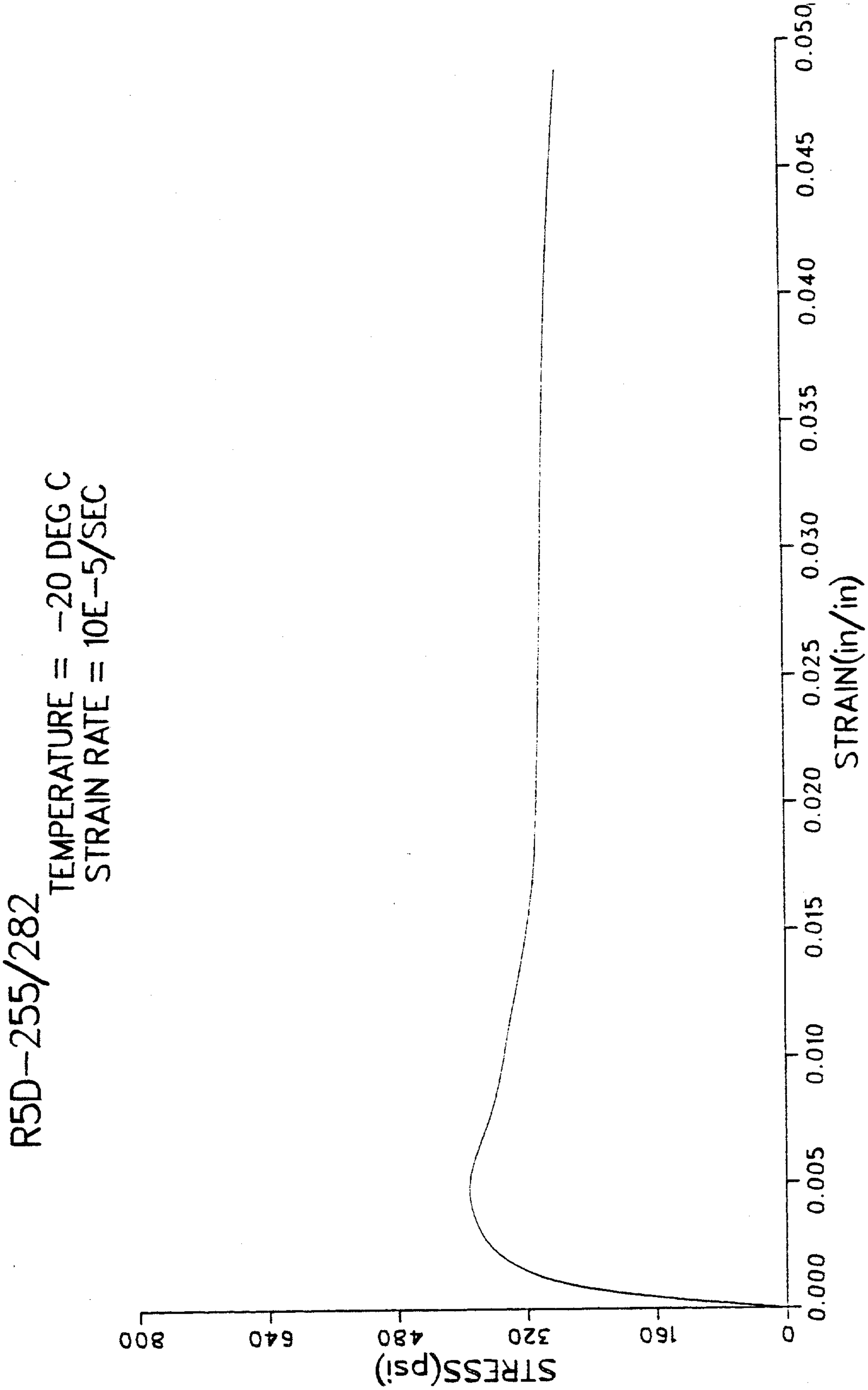

R3C-411/438
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

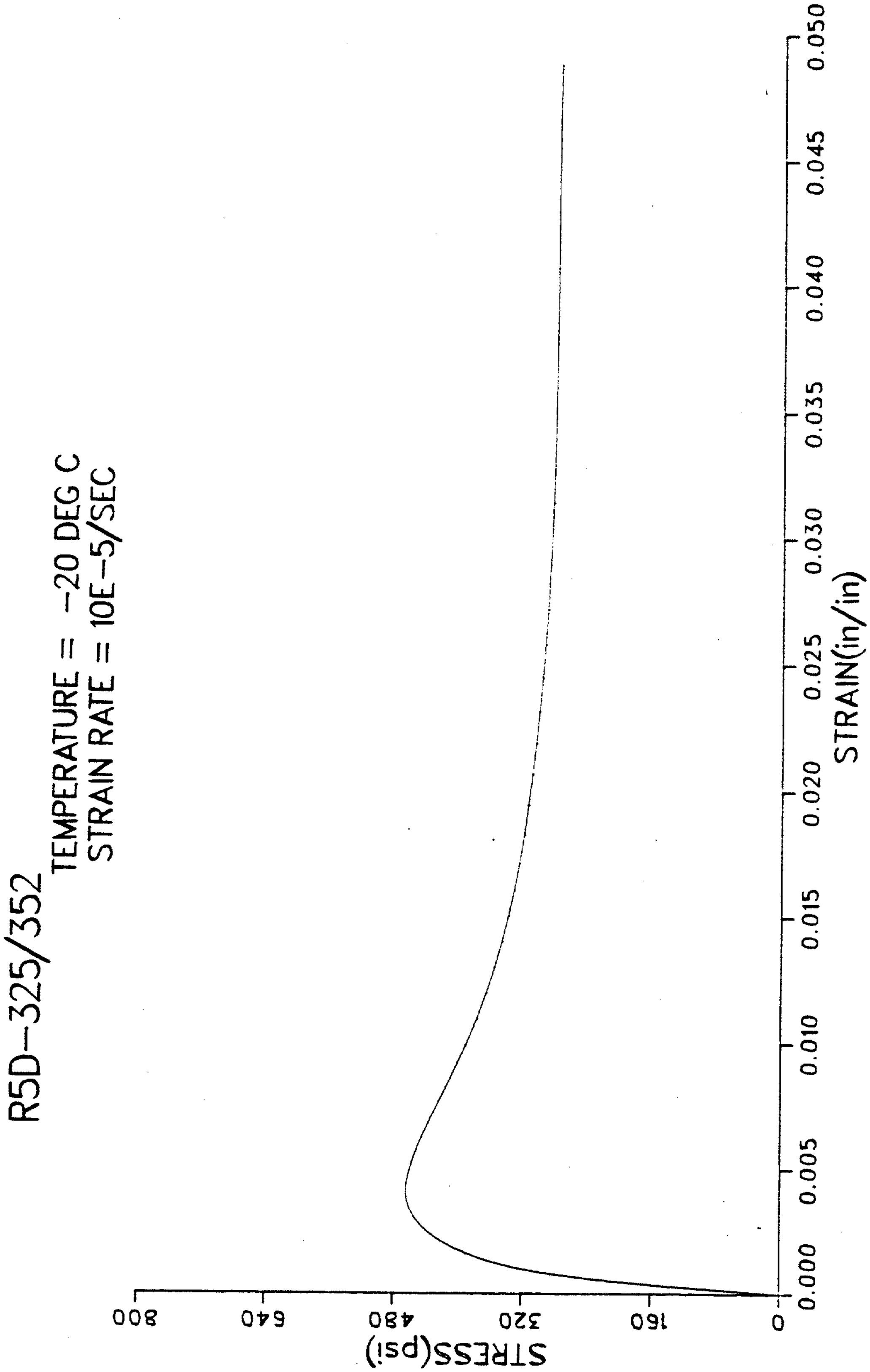

R3D-250/277
TEMPERATURE = −20 DEG C
STRAIN RATE = 10E−5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

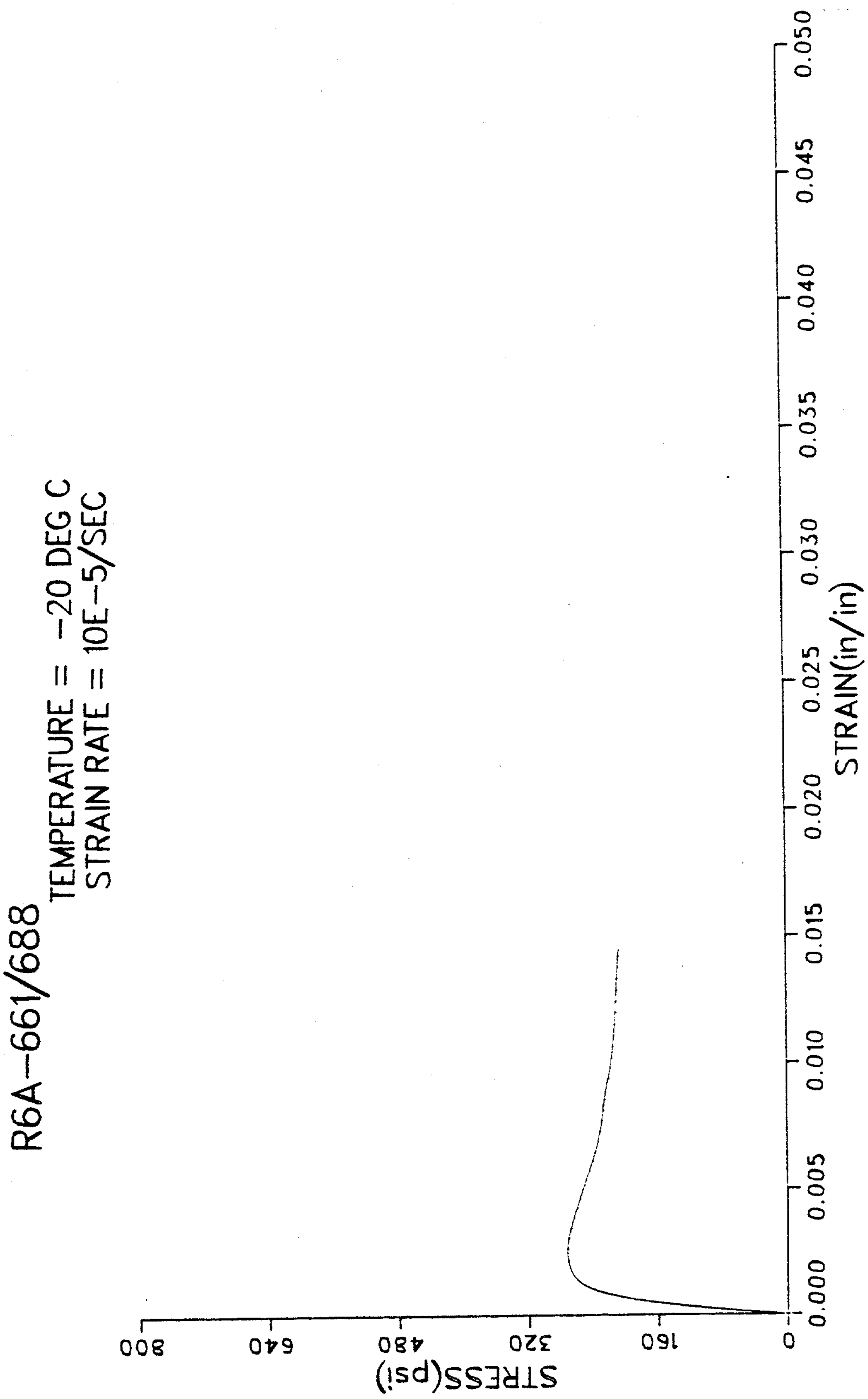

R3D-318/345
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

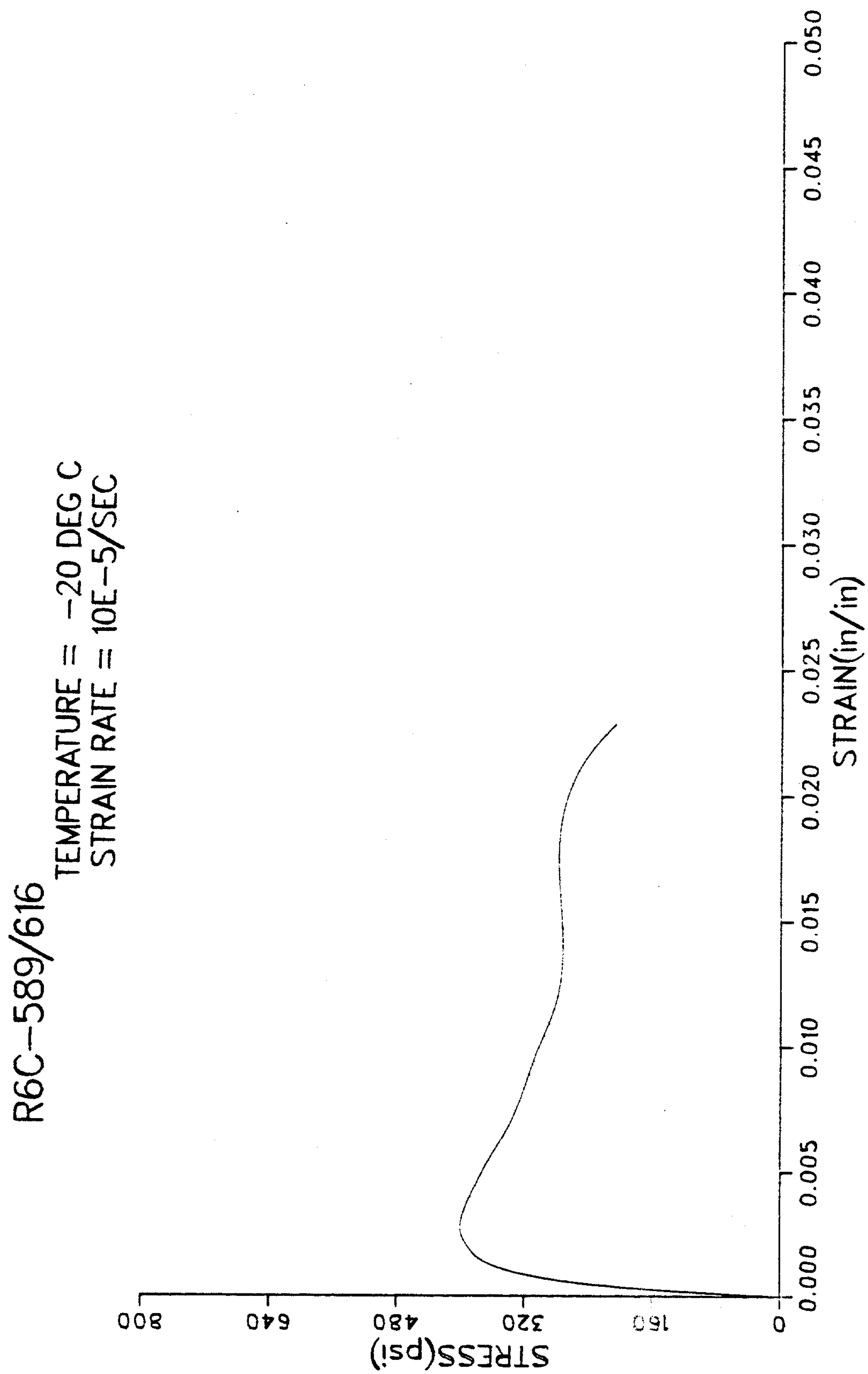

R5C-250/277
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

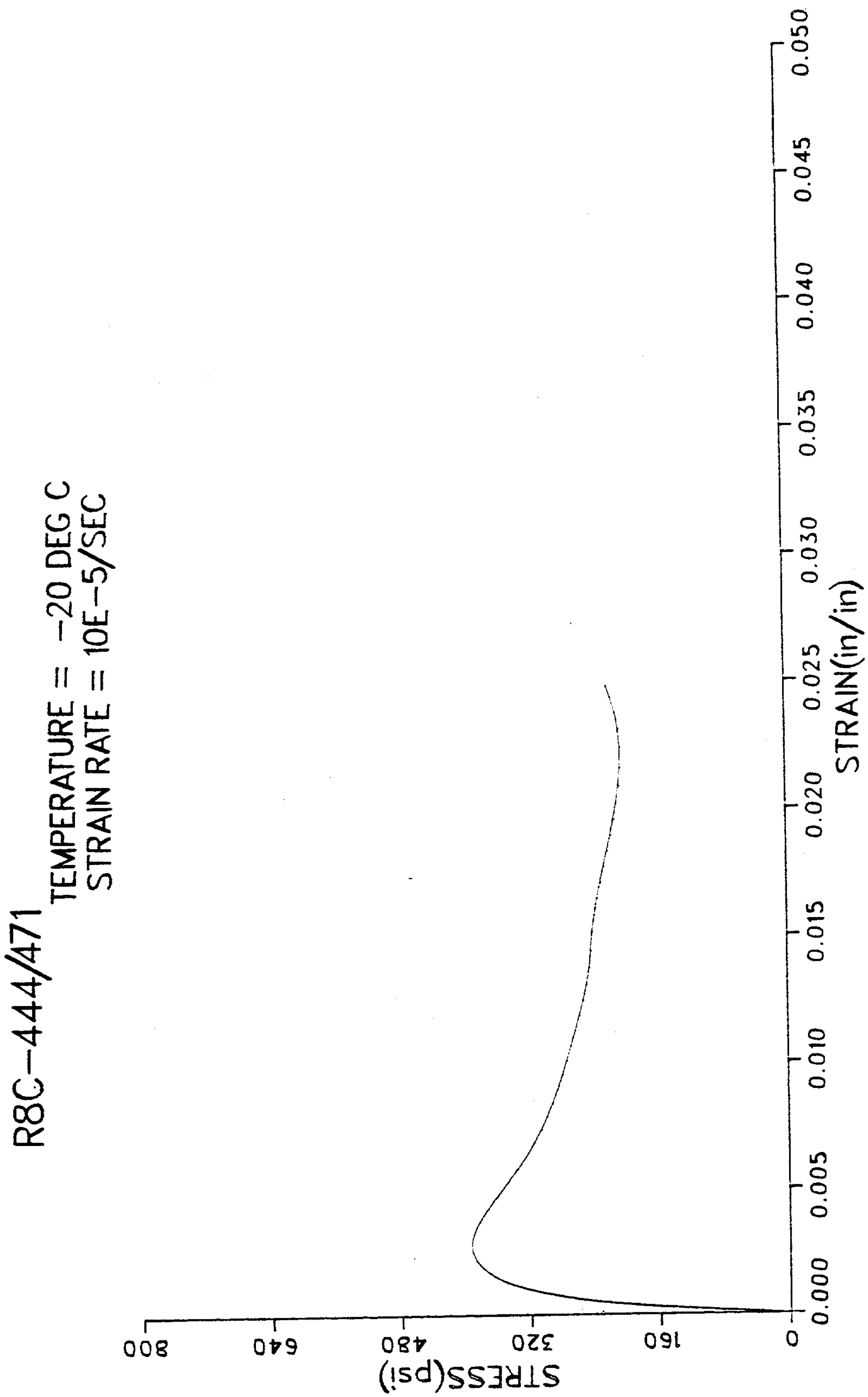

R5C-328/355
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

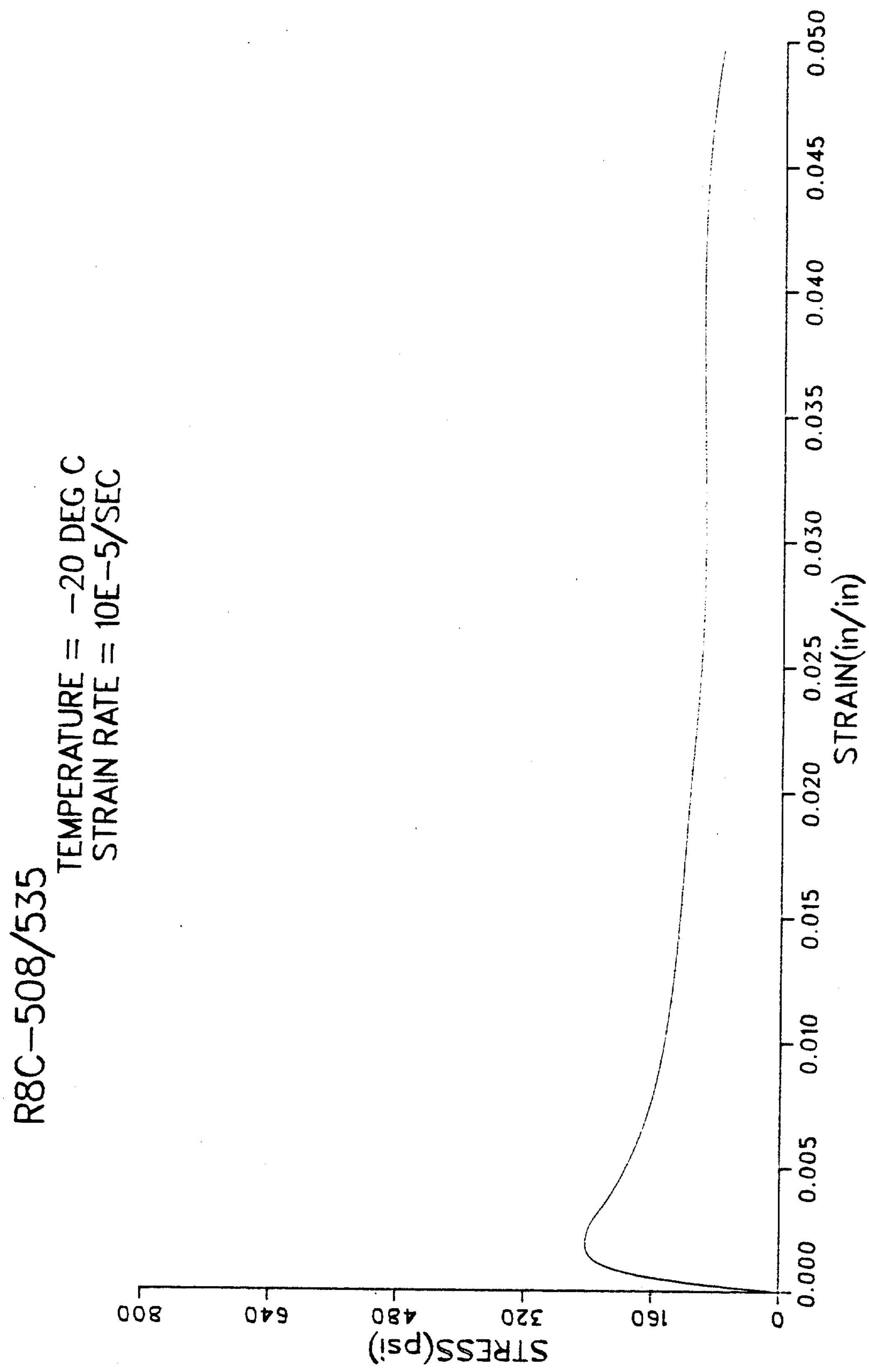

R5D-255/282
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

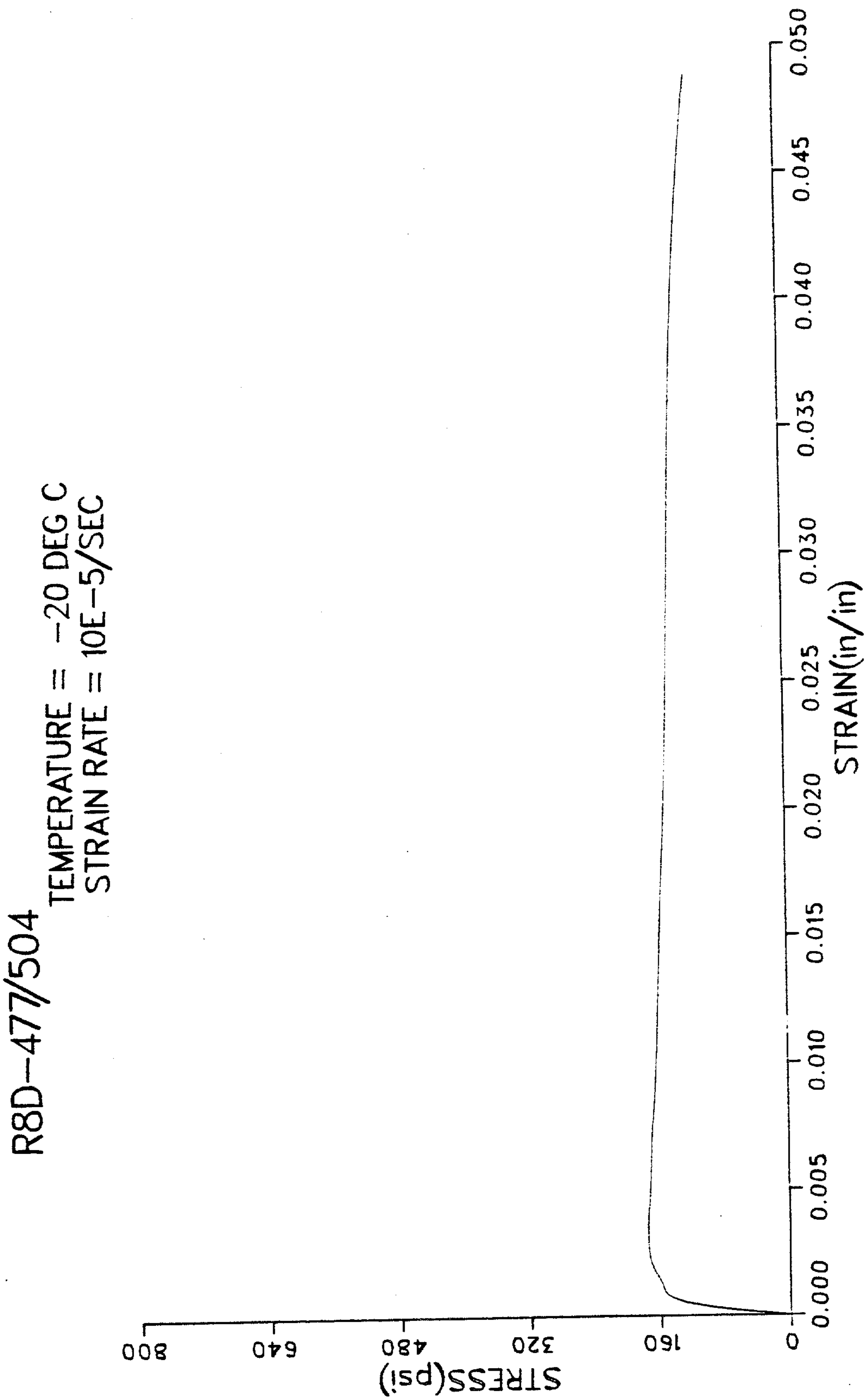

R5D–325/352
TEMPERATURE = –20 DEG C
STRAIN RATE = 10E–5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

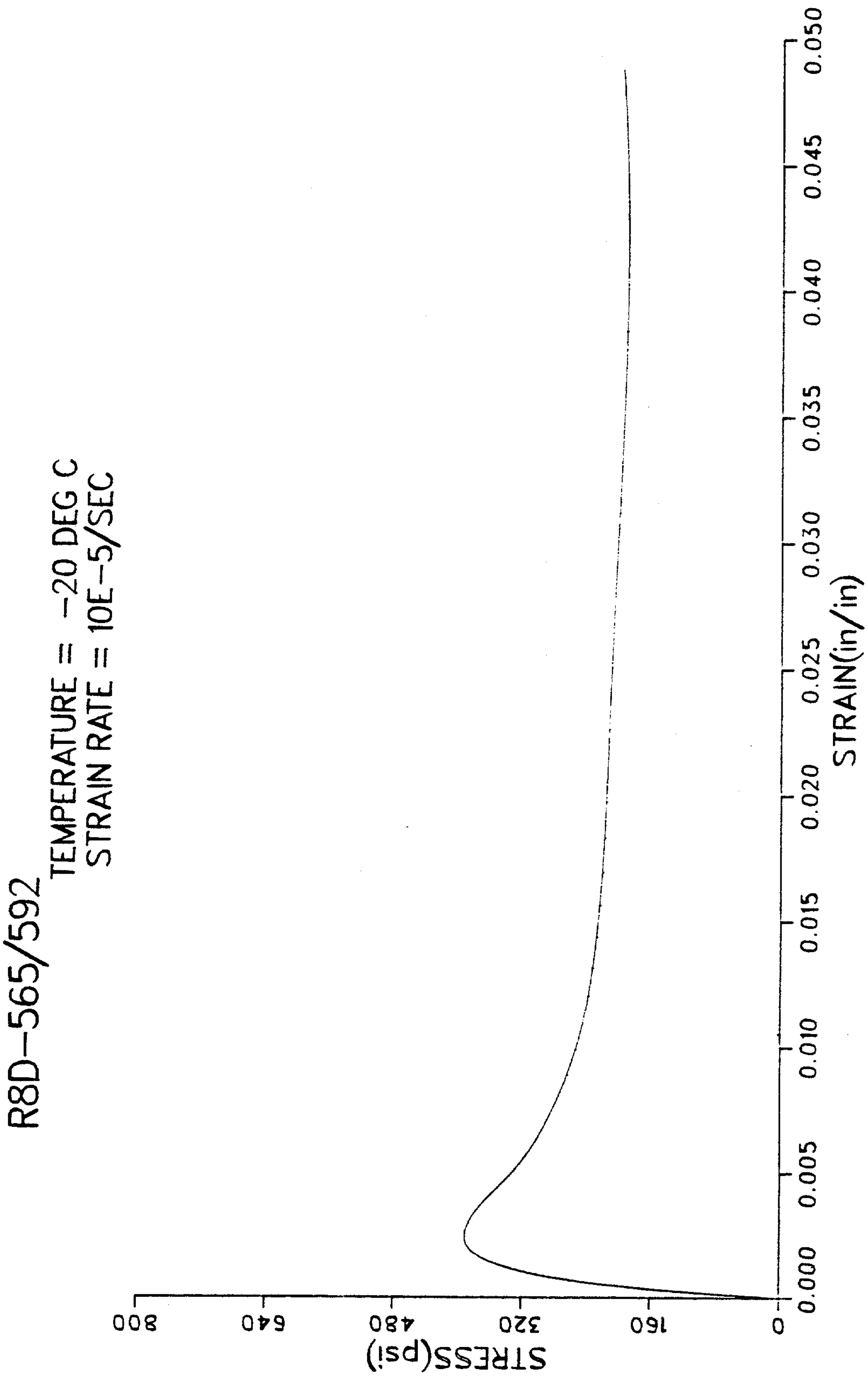

R6A–661/688
TEMPERATURE = –20 DEG C
STRAIN RATE = 10E–5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

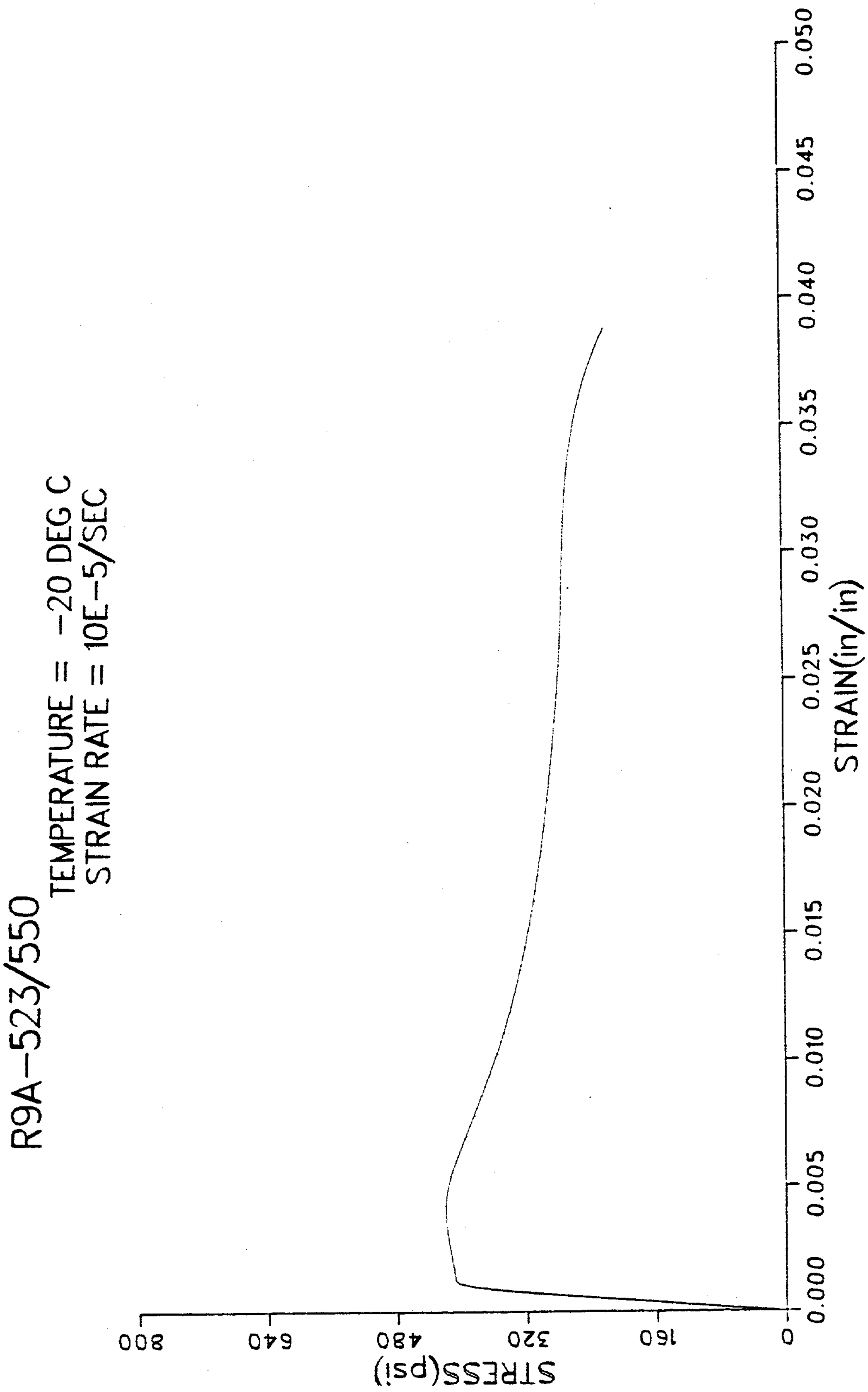

R6C-589/616
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

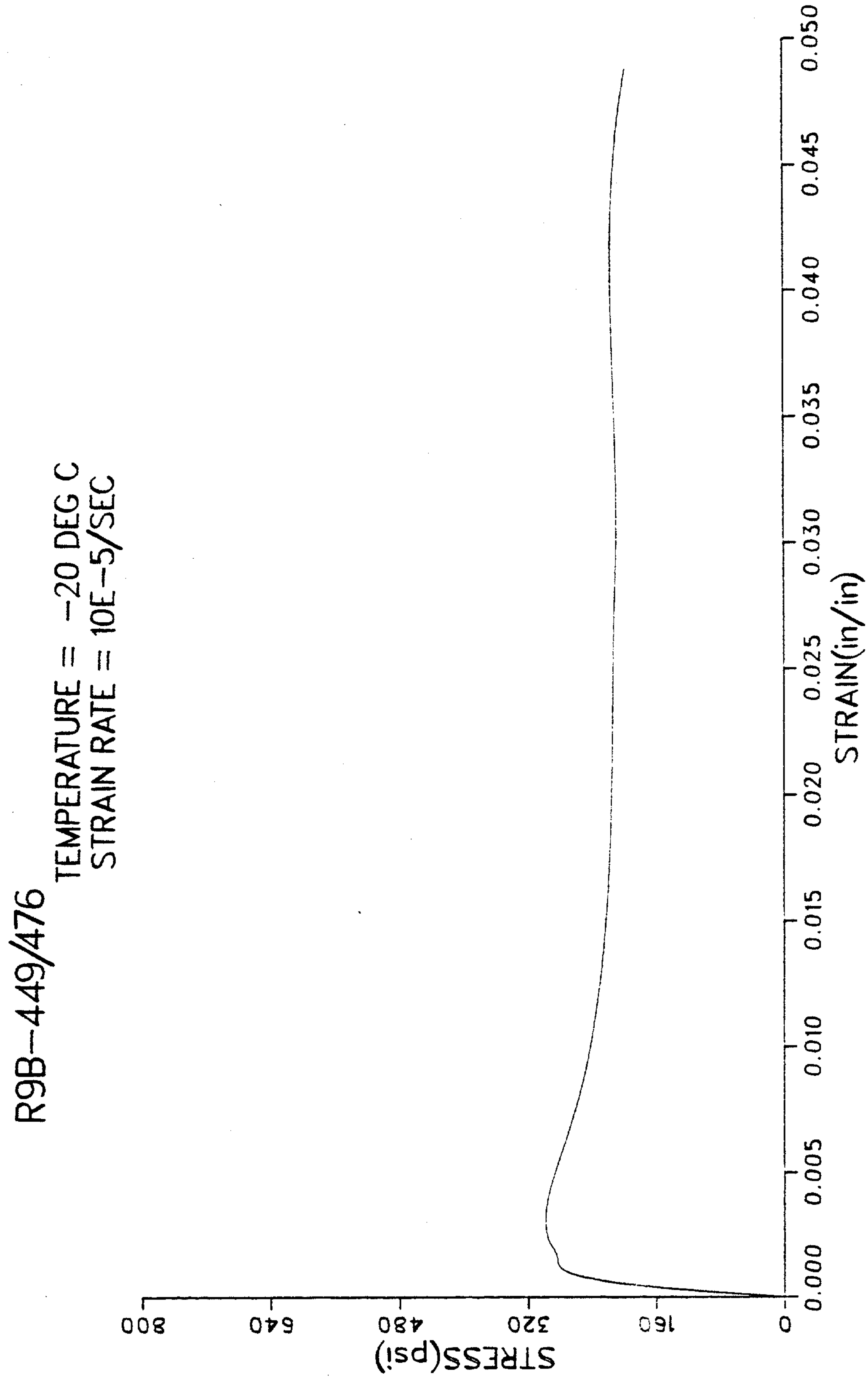

R8C-4444/471
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

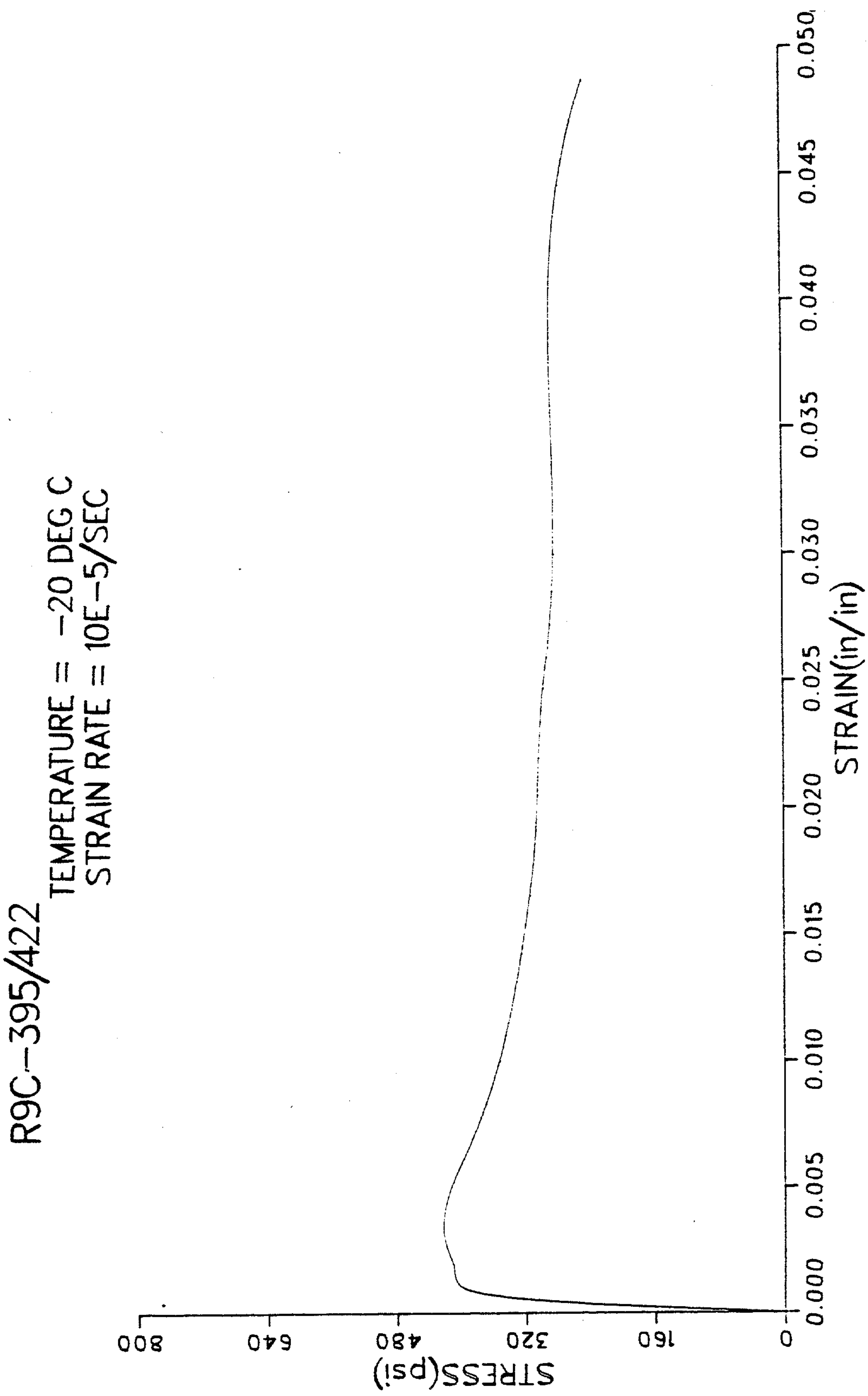

R8C–508/535
TEMPERATURE = –20 DEG C
STRAIN RATE = 10E–5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

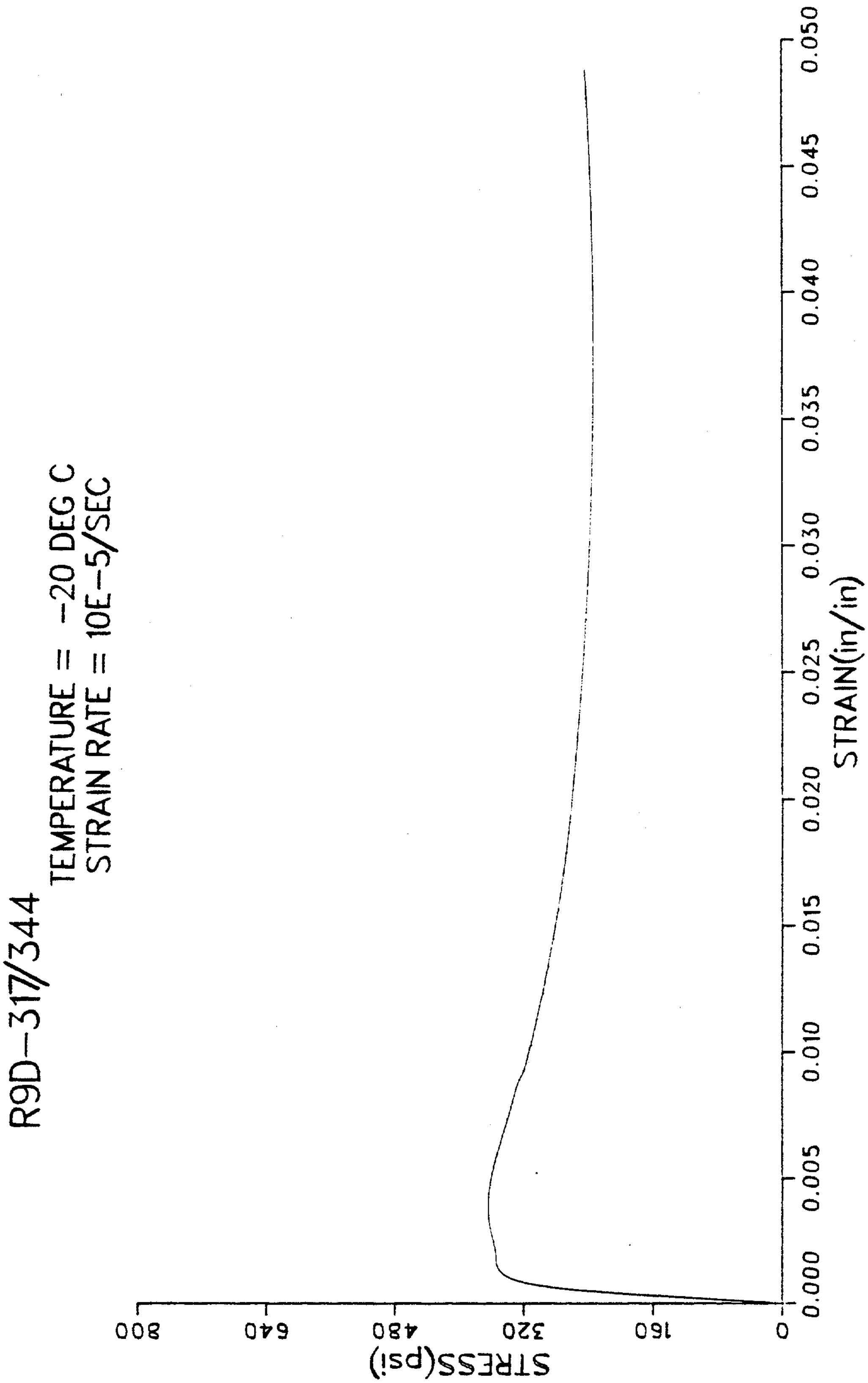

R8D-477/504
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

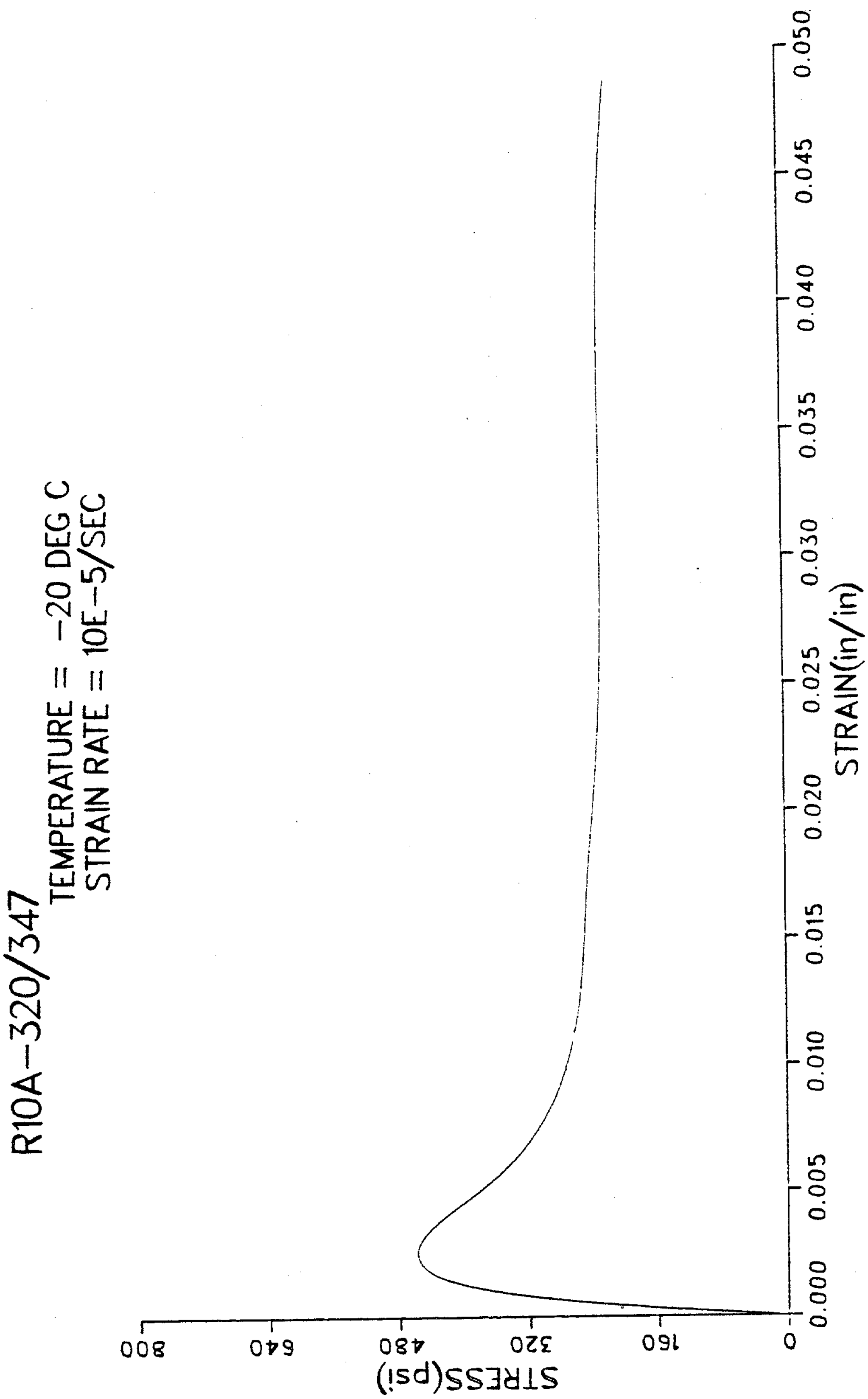

R8D-565/592
TEMPERATURE = −20 DEG C
STRAIN RATE = 10E−5/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
160
320
480
640
800

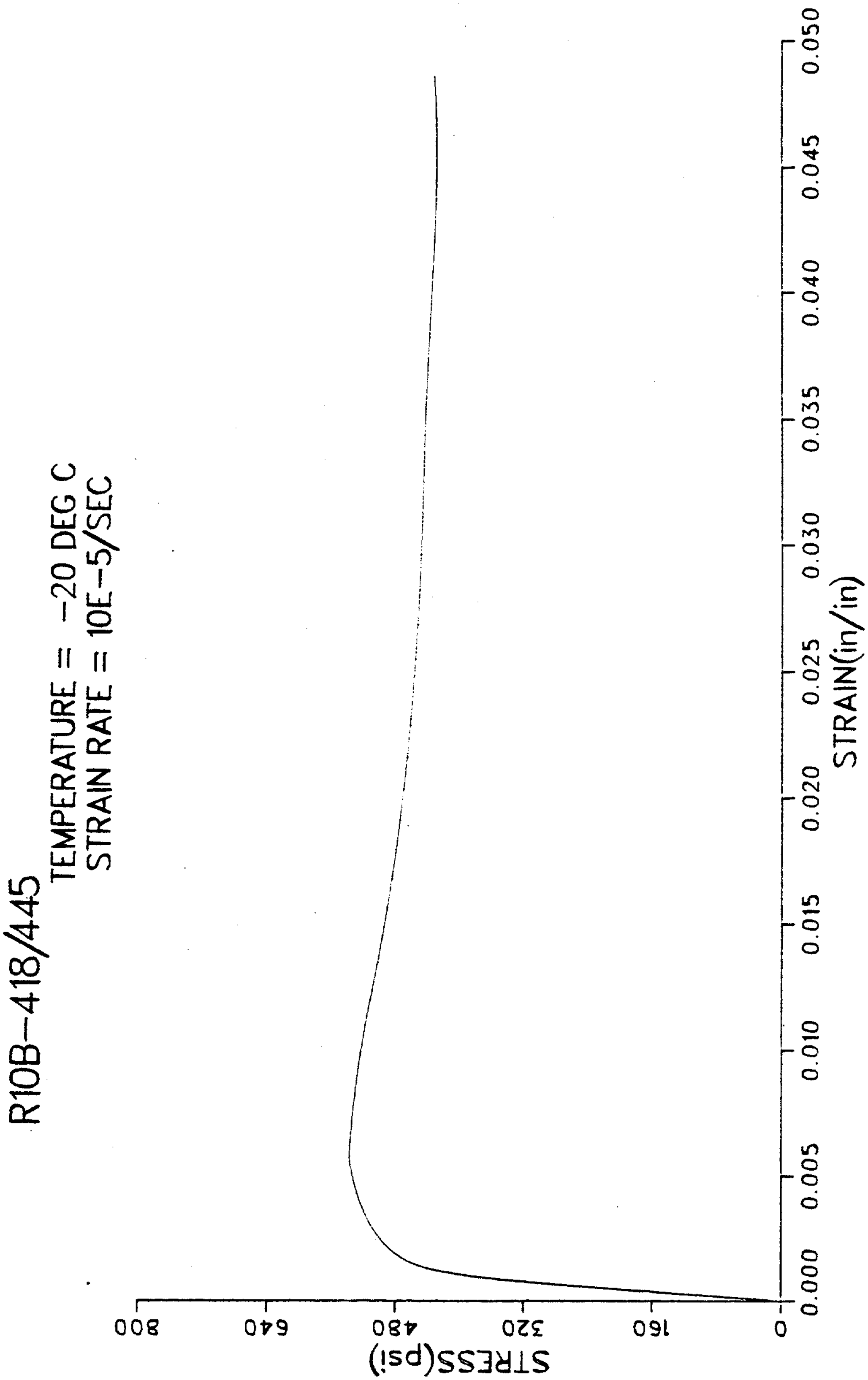

R9A-523/550
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050


R9B–449/476
TEMPERATURE = –20 DEG C
STRAIN RATE = 10E–5/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
160
320
480
640
800

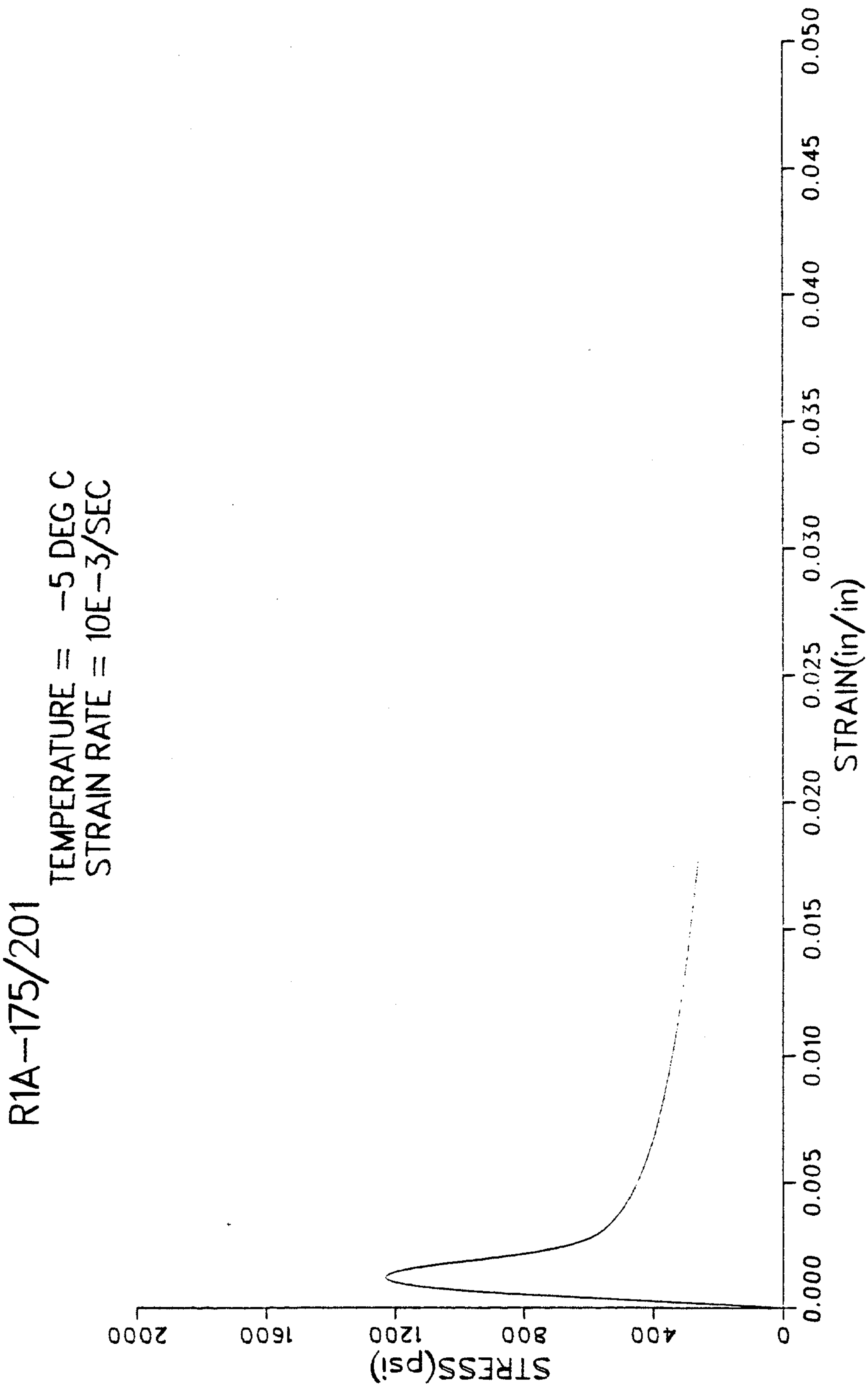

R9C-395/422
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

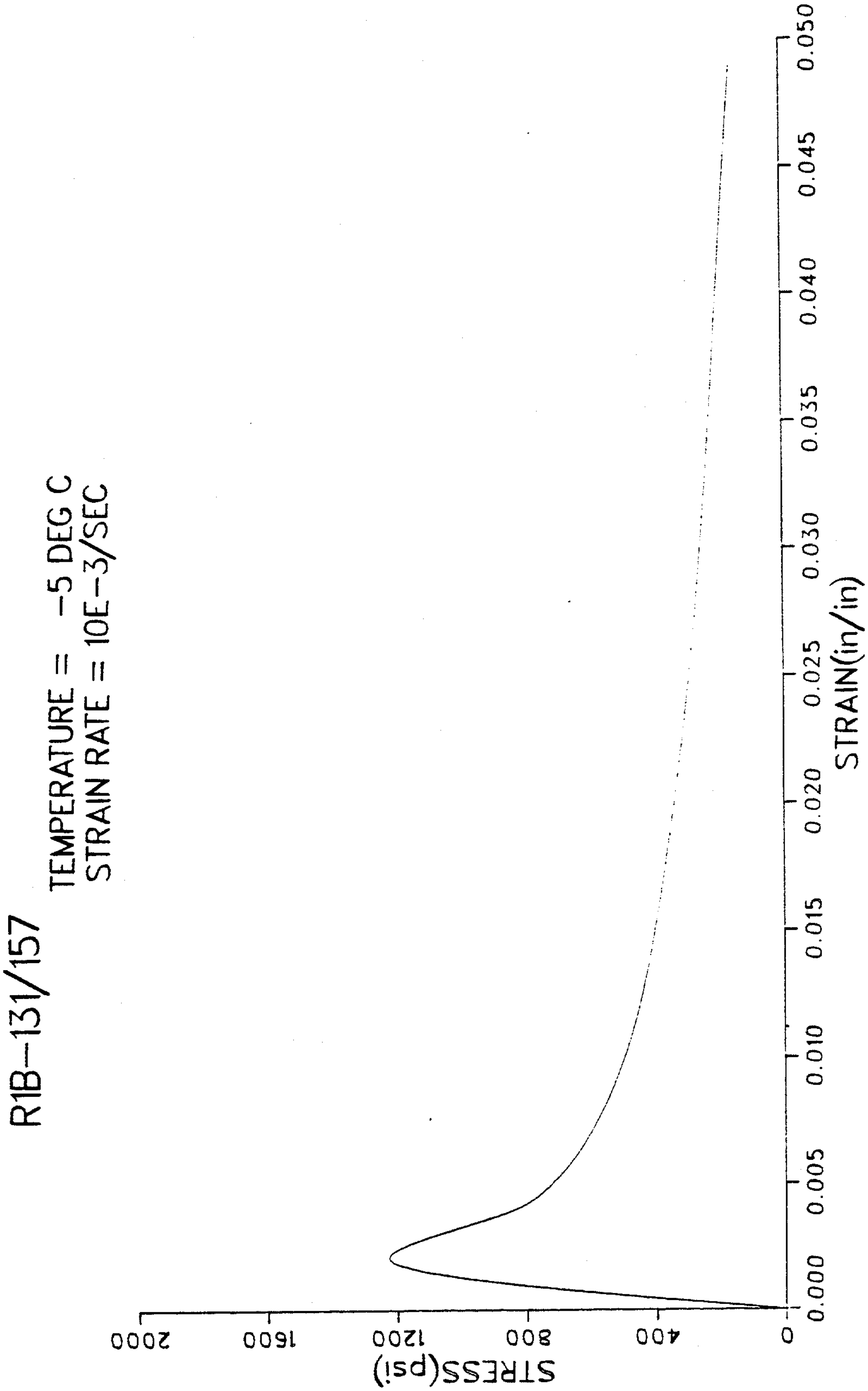

R9D-317/344
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

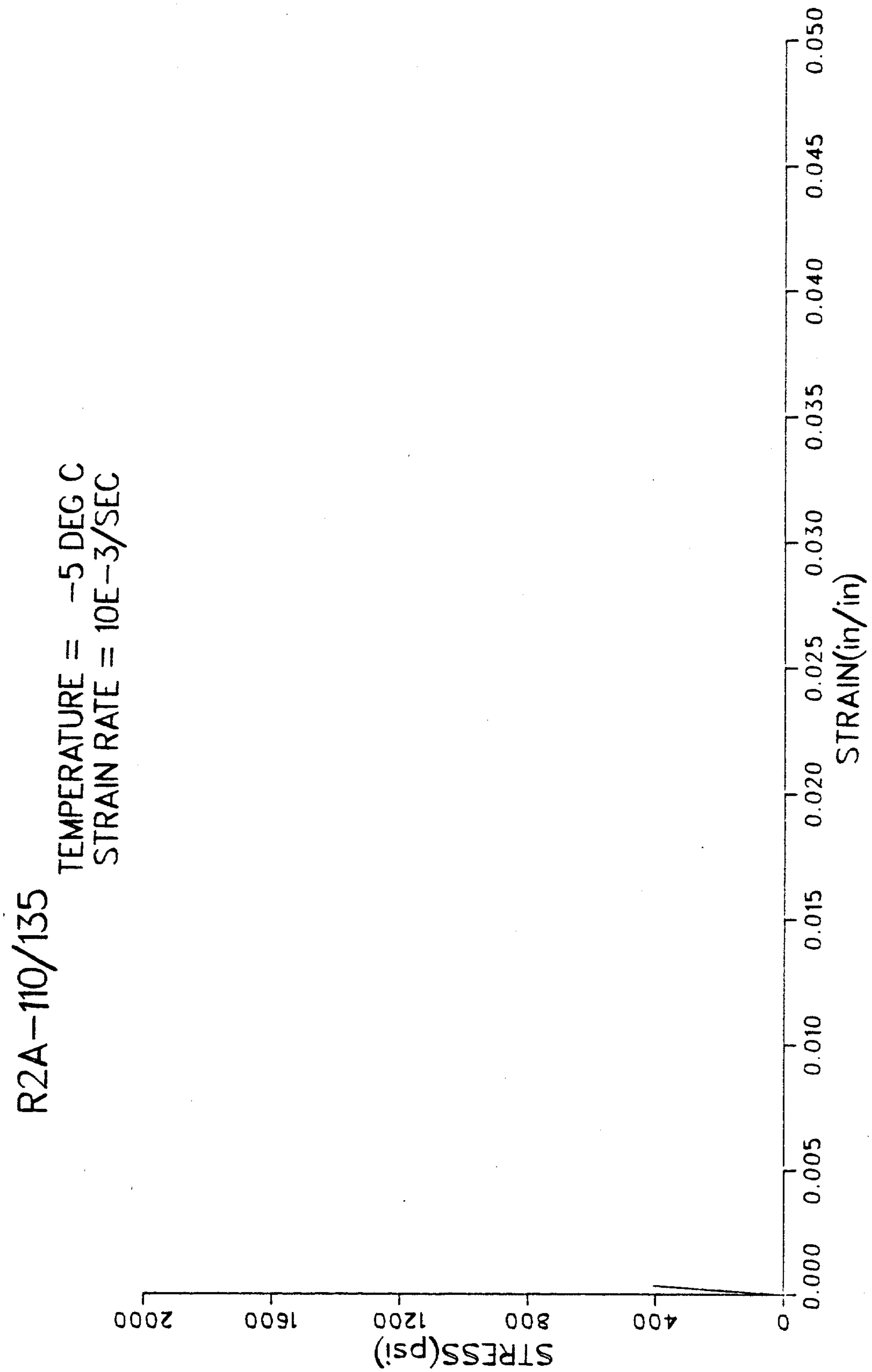

R10A–320/347
TEMPERATURE = –20 DEG C
STRAIN RATE = 10E–5/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
160
320
480
640
800

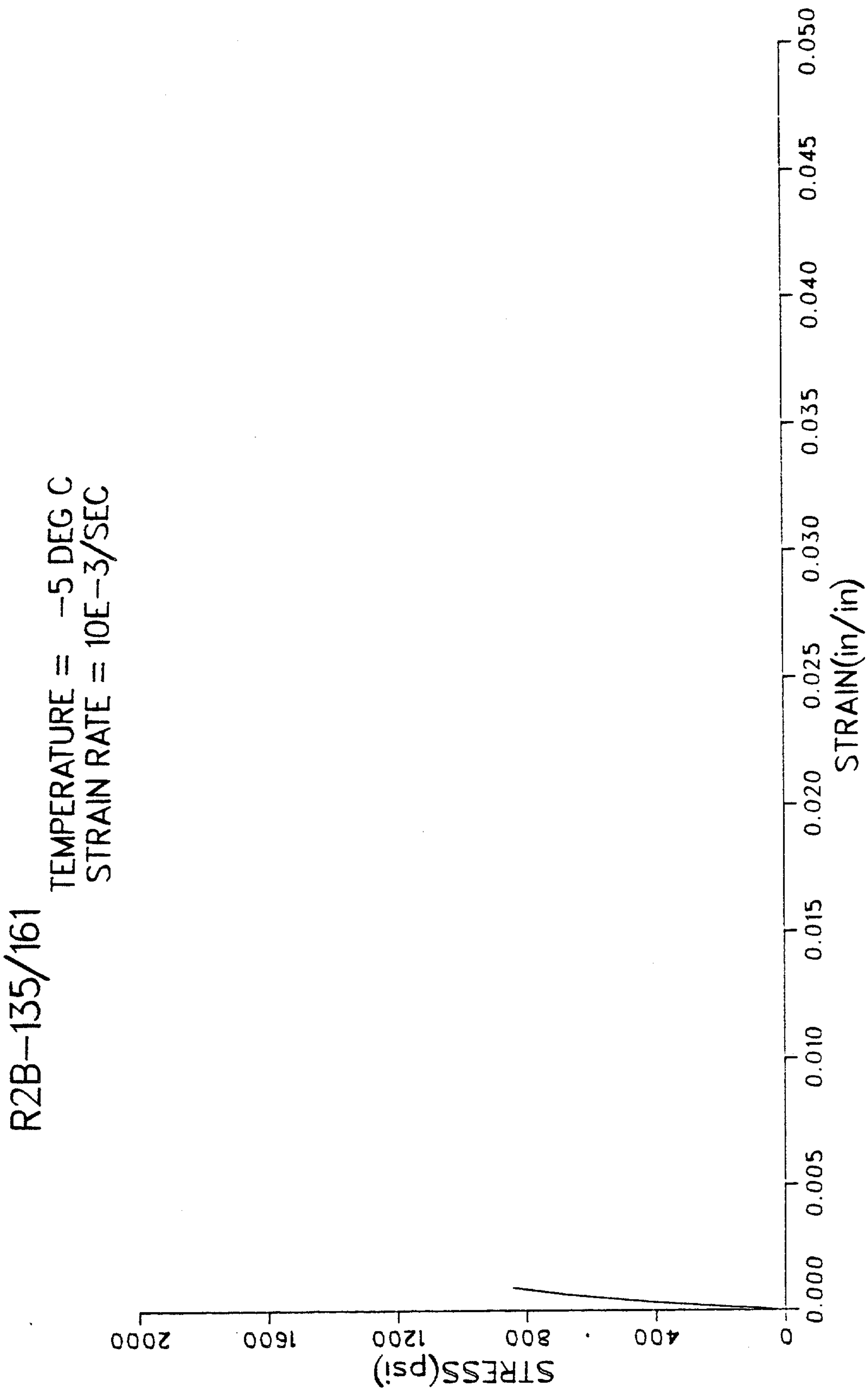

R10B-418/445
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-5/SEC
STRESS(psi)
0
160
320
480
640
800
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

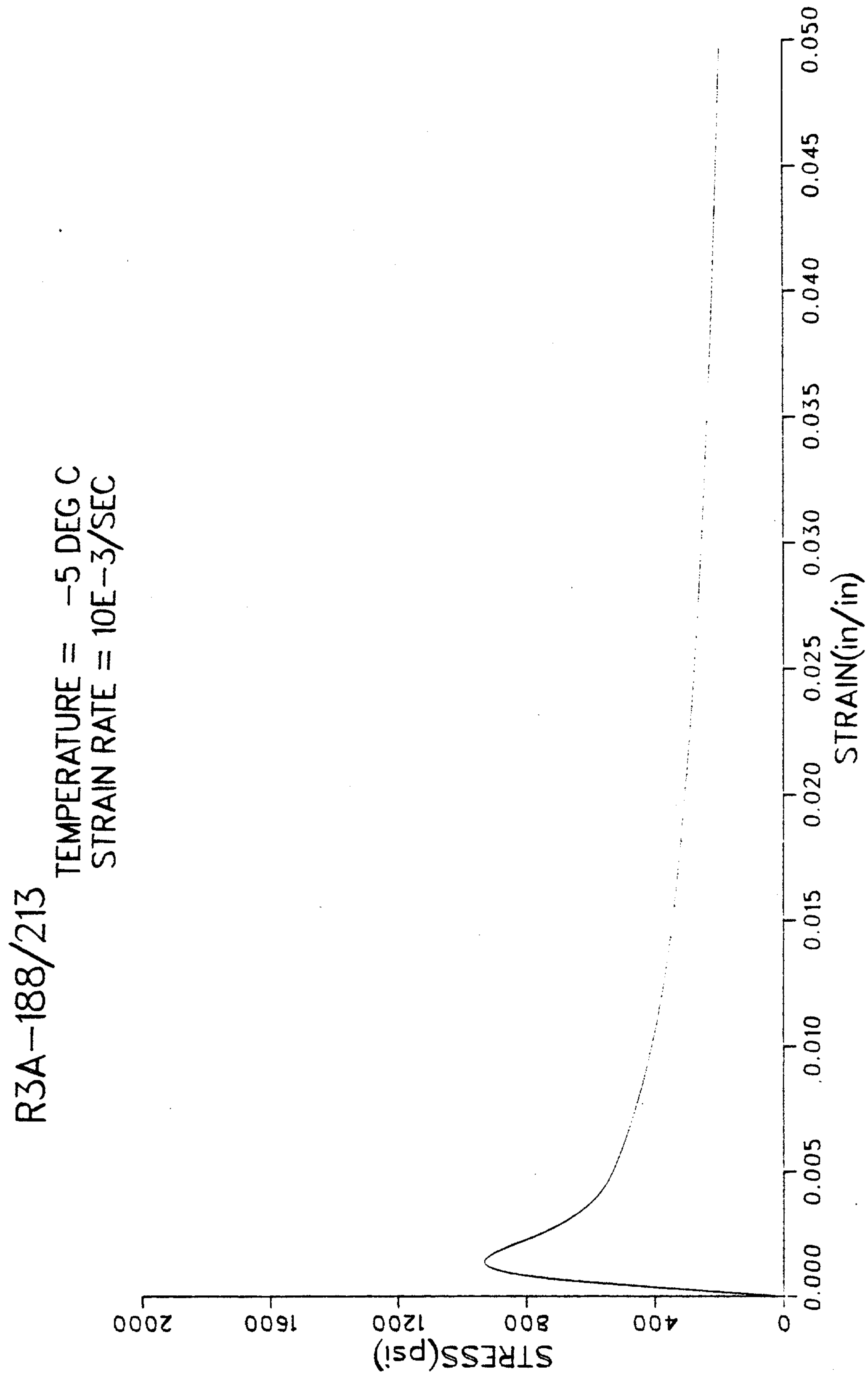
STRAIN RATE = (10E-3)/SEC
TEMPERATURE = -5°C

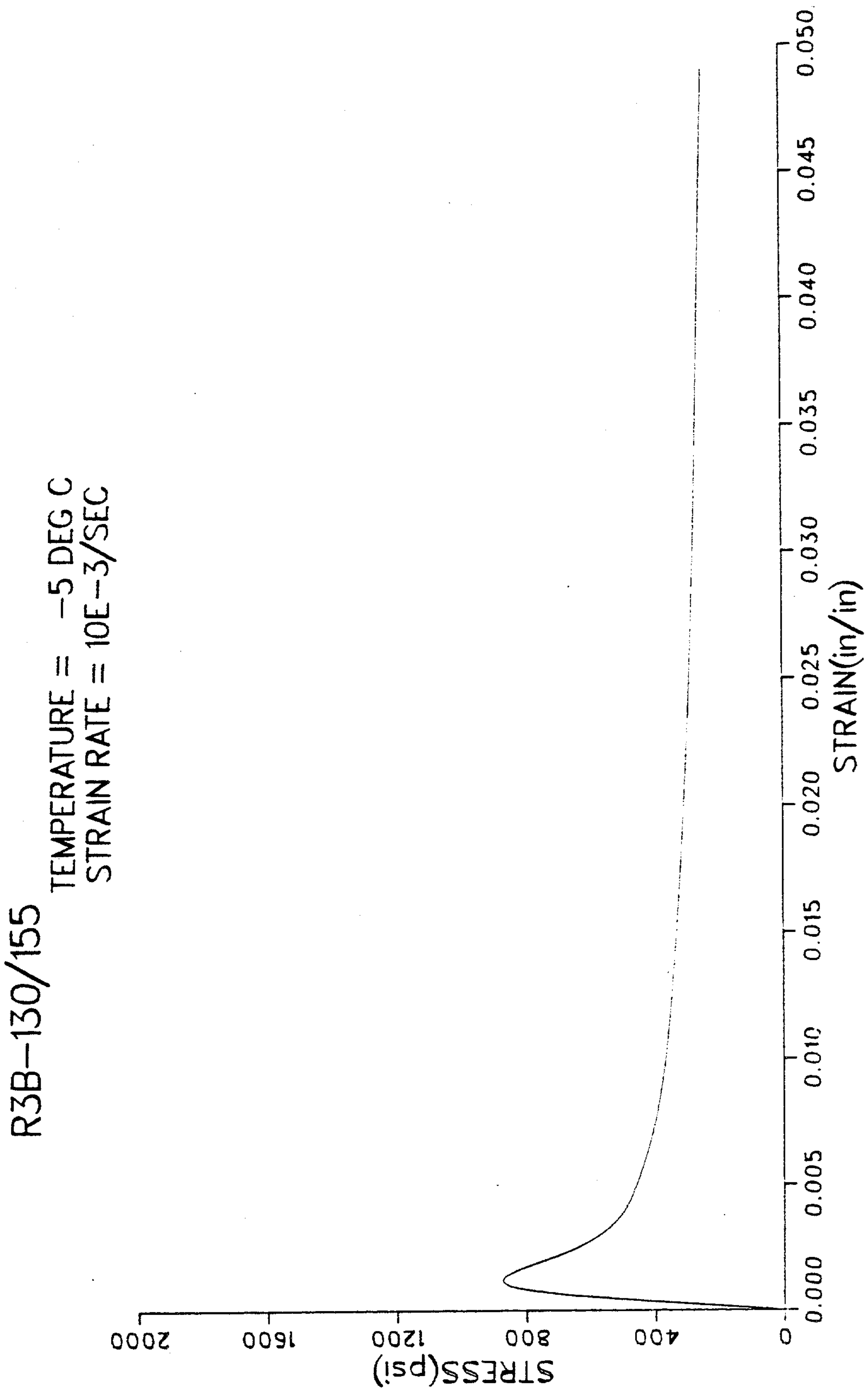

R1A–175/201
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–3/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
400
800
1200
1600
2000

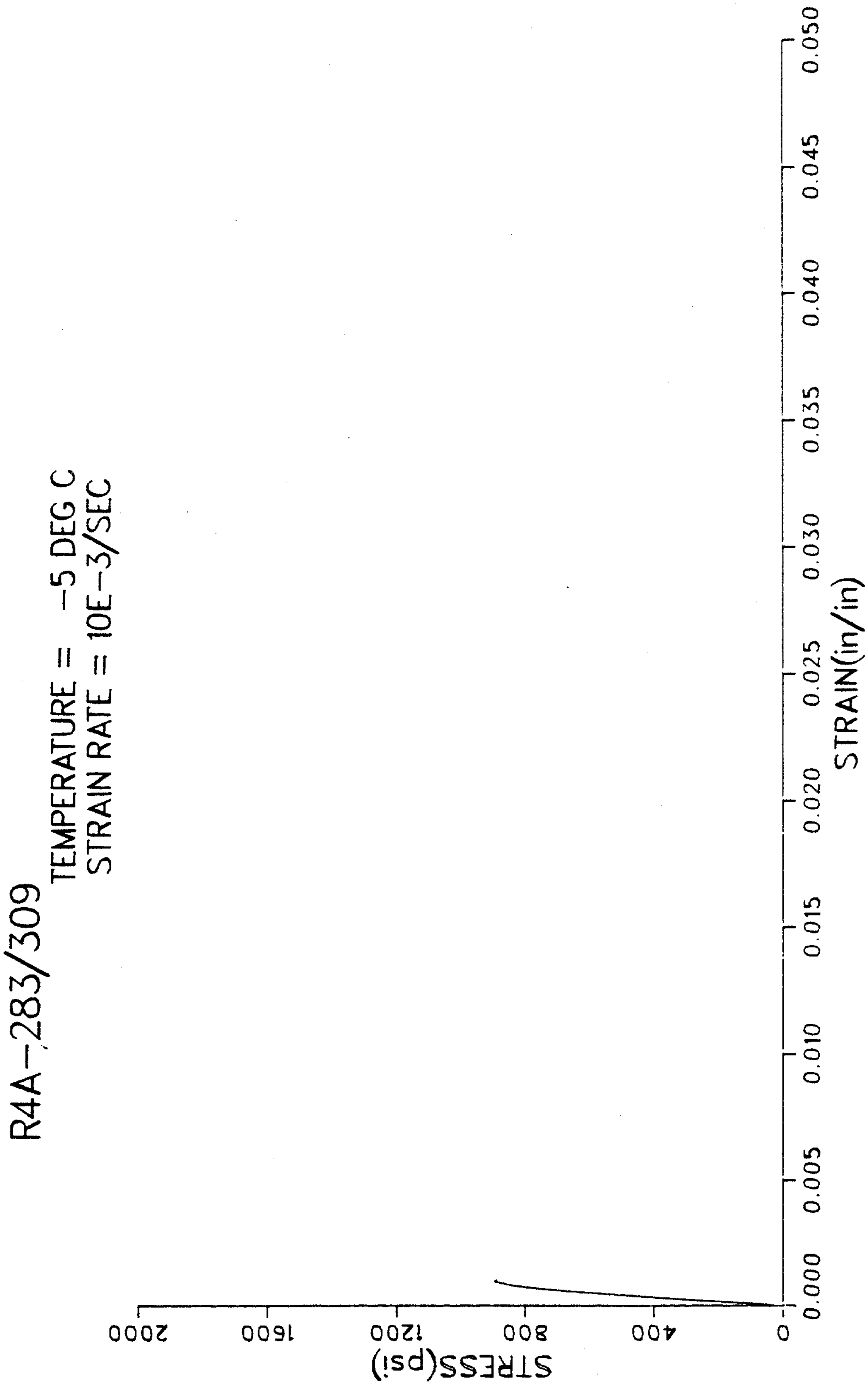

R1B–131/157
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–3/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
400
800
1200
1600
2000

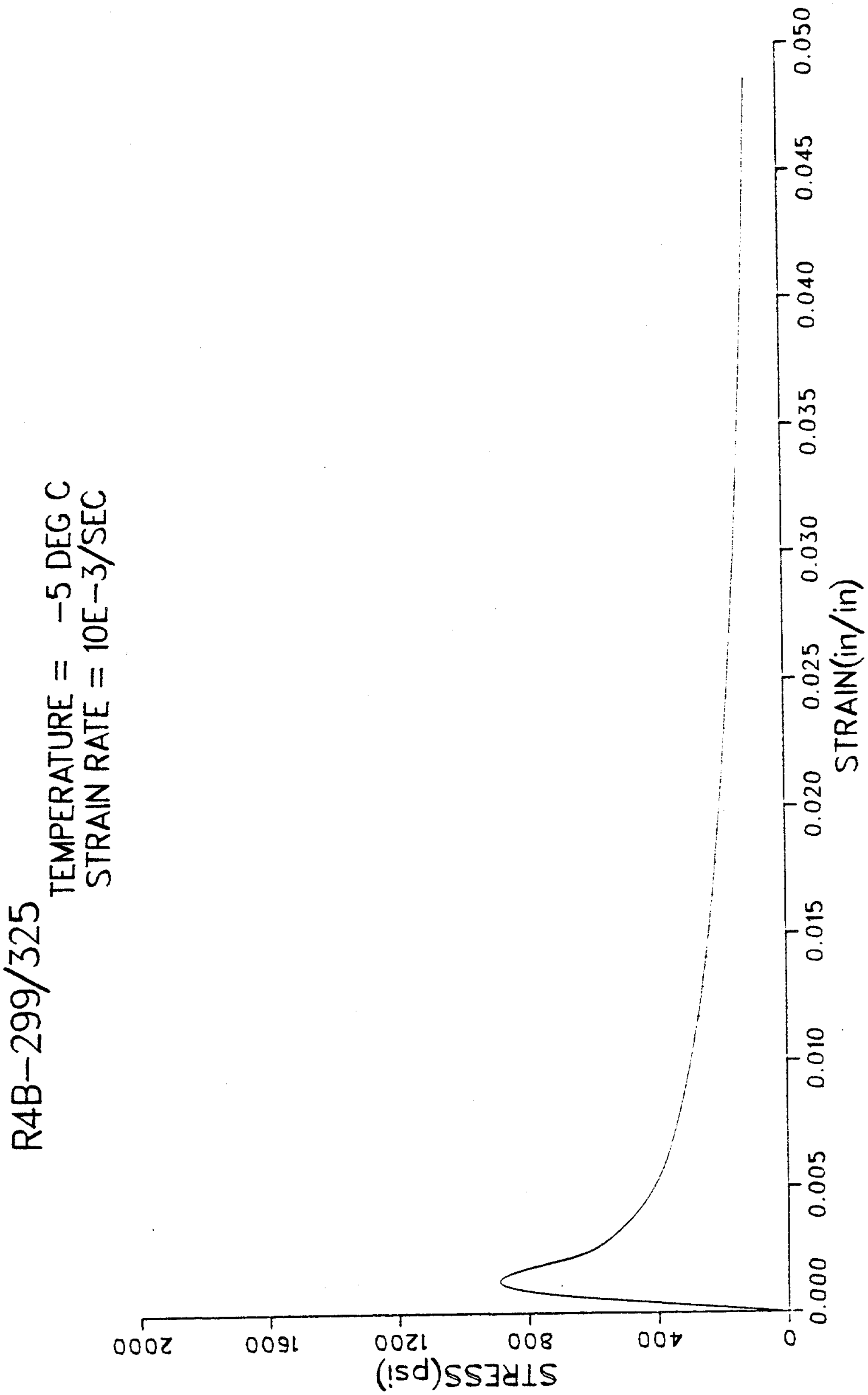

R2A-110/135
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

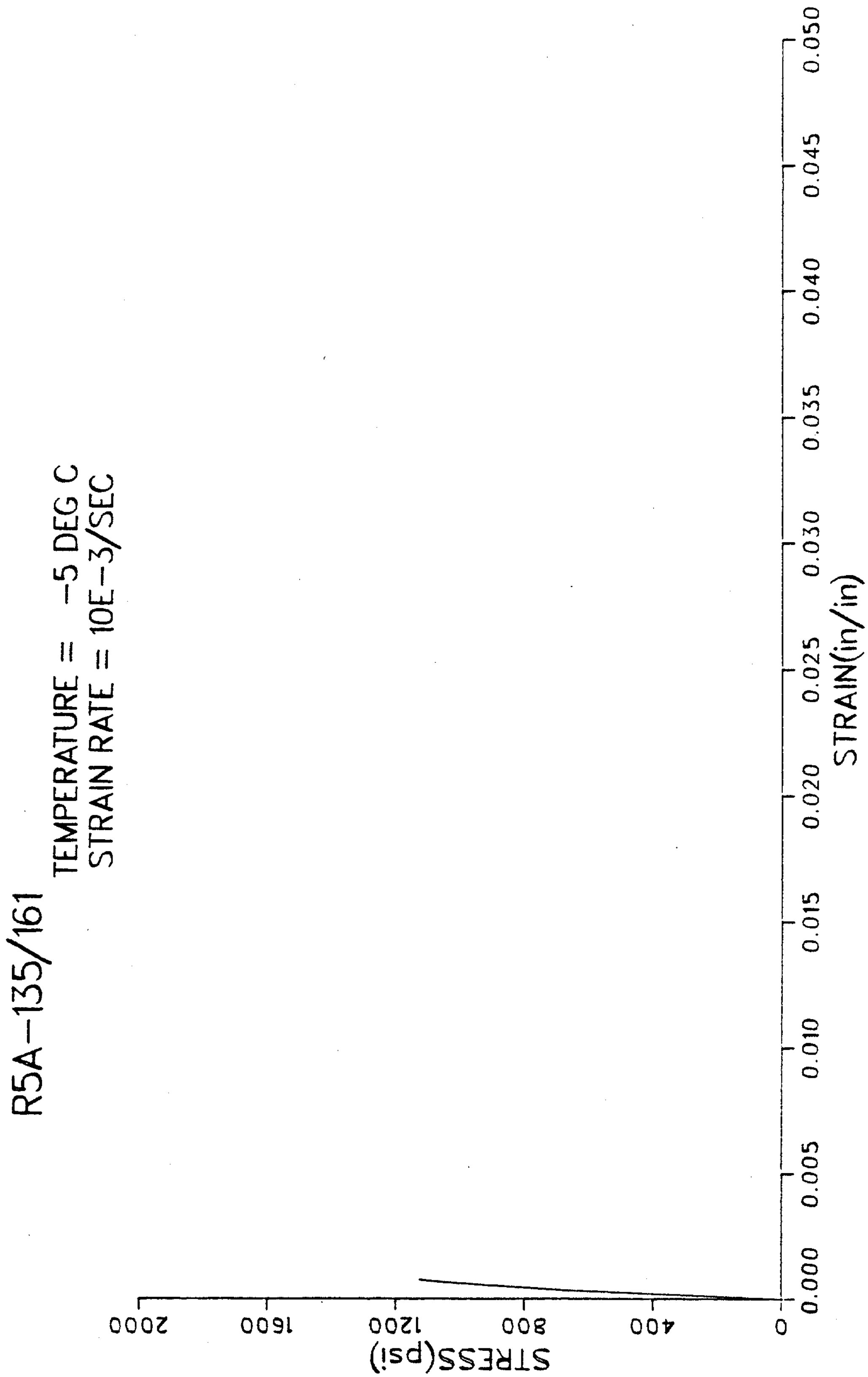

R2B-135/161
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

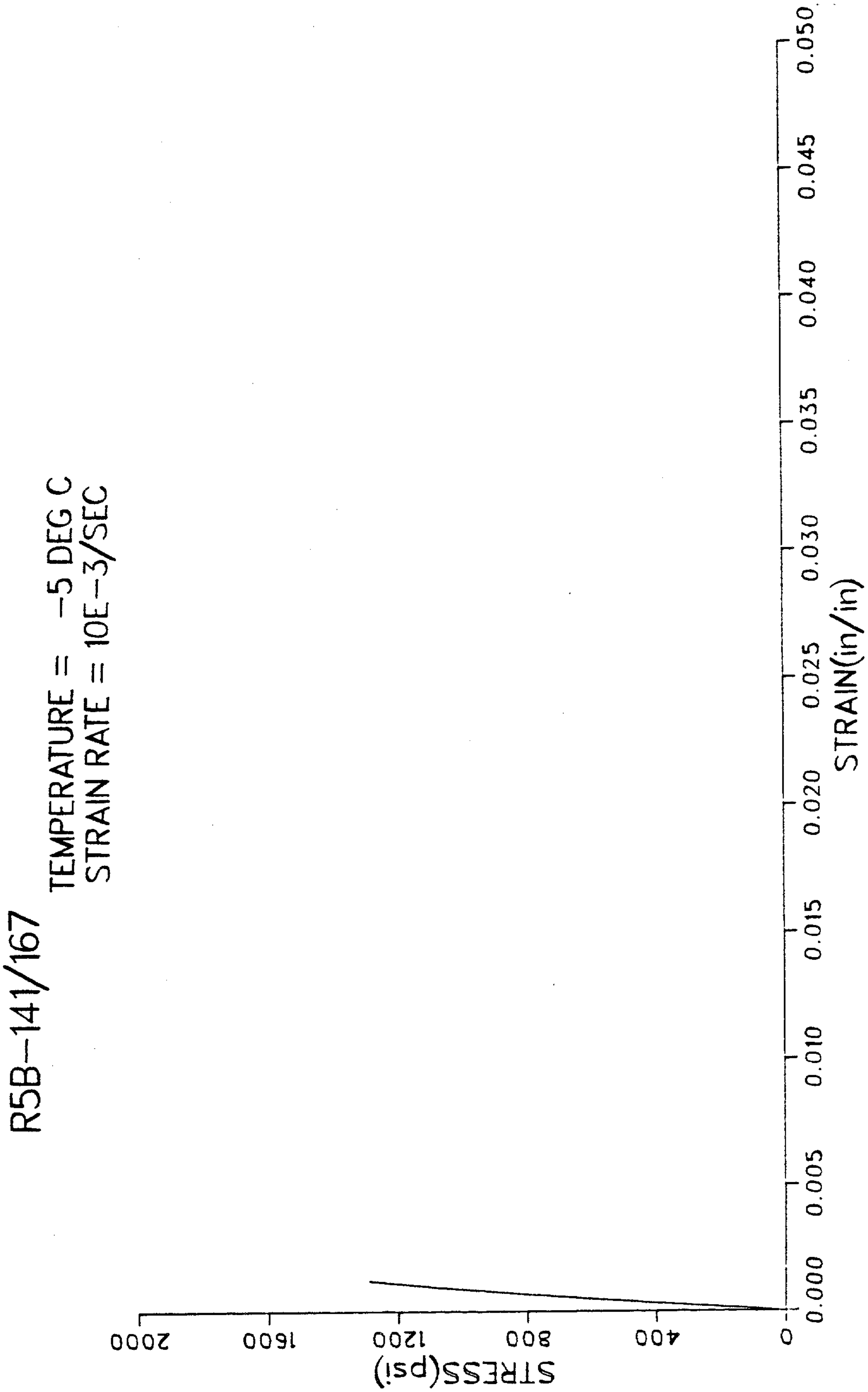

R3A–188/213
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

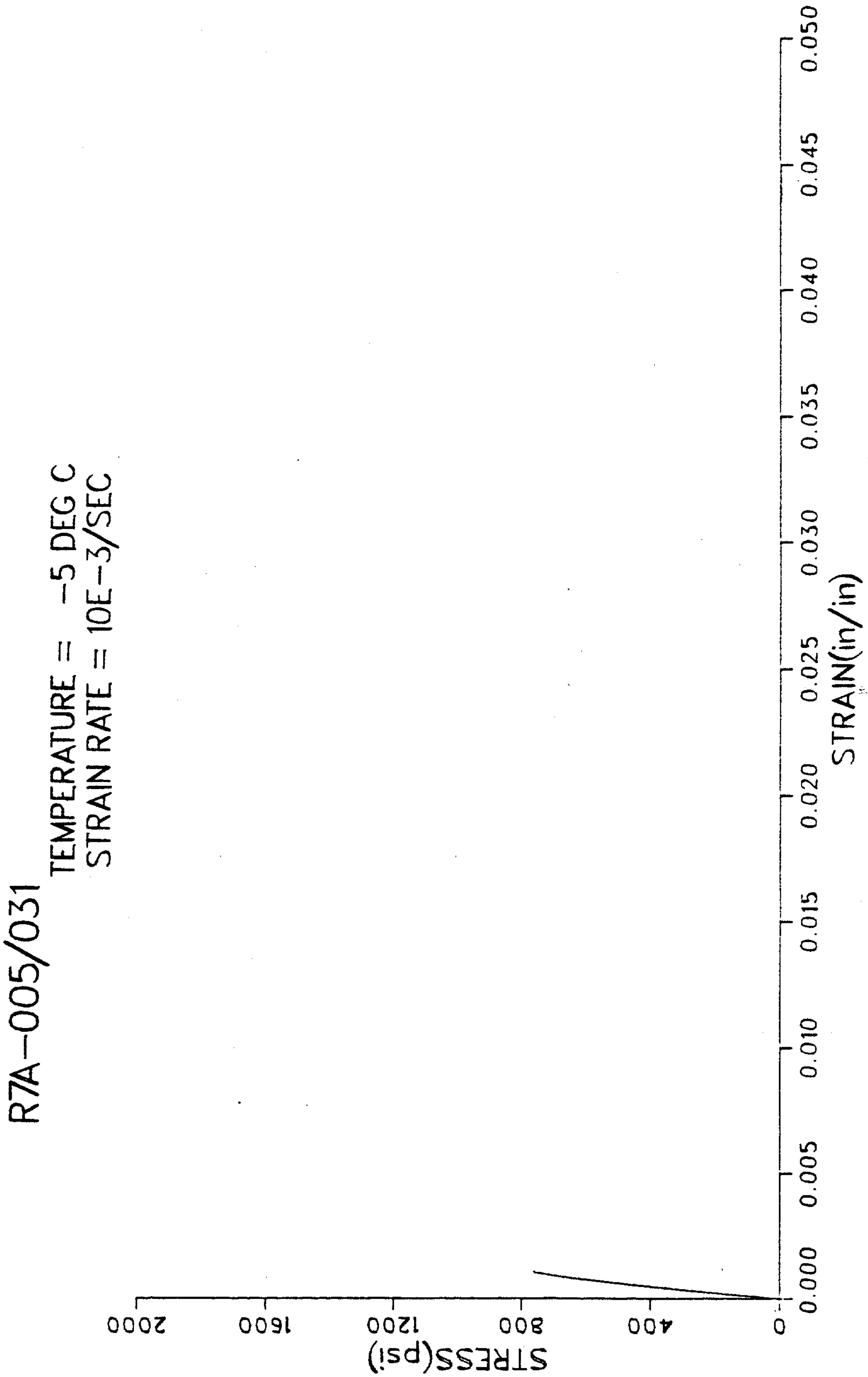

R3B-130/155
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

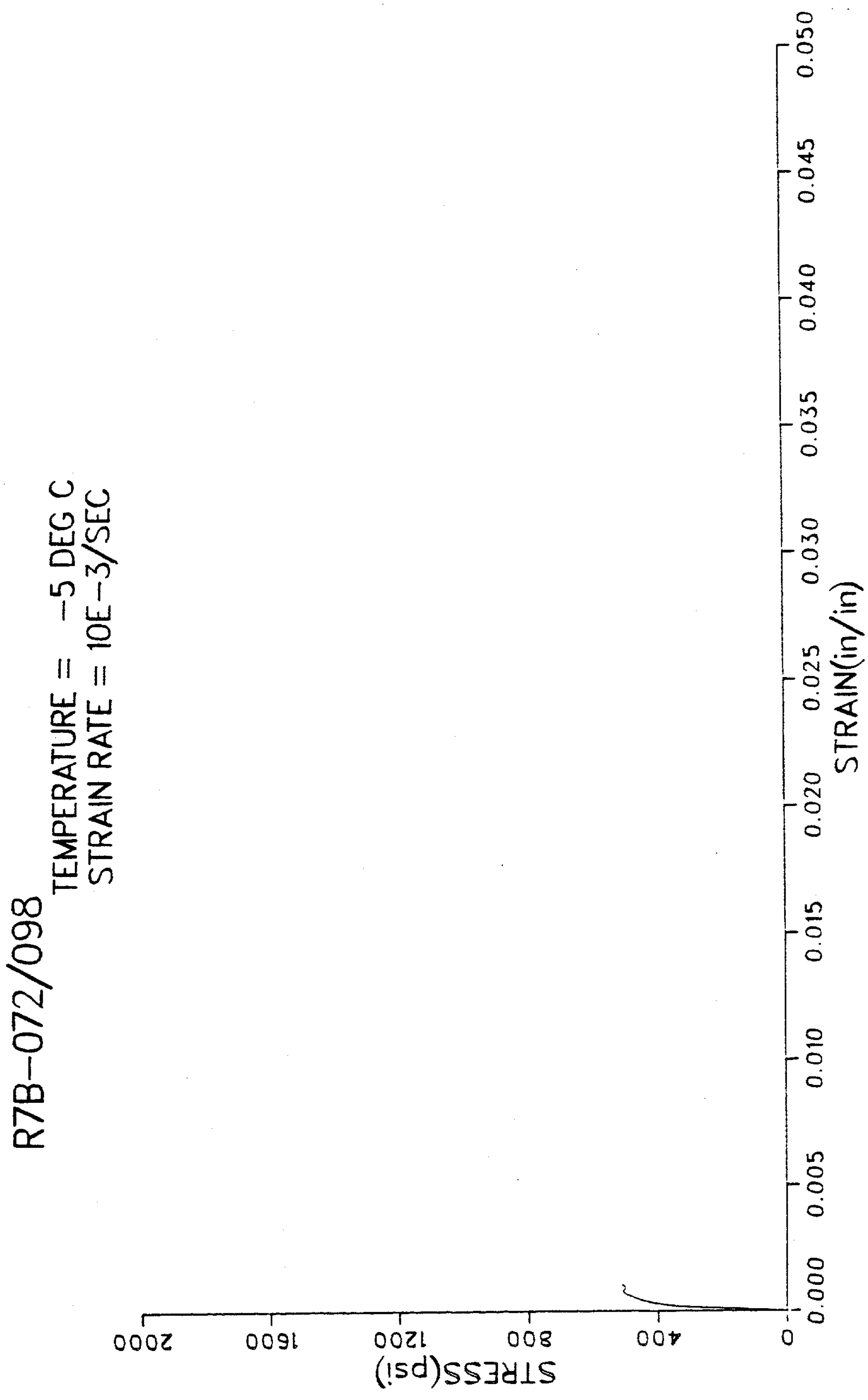

R4A-283/309
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

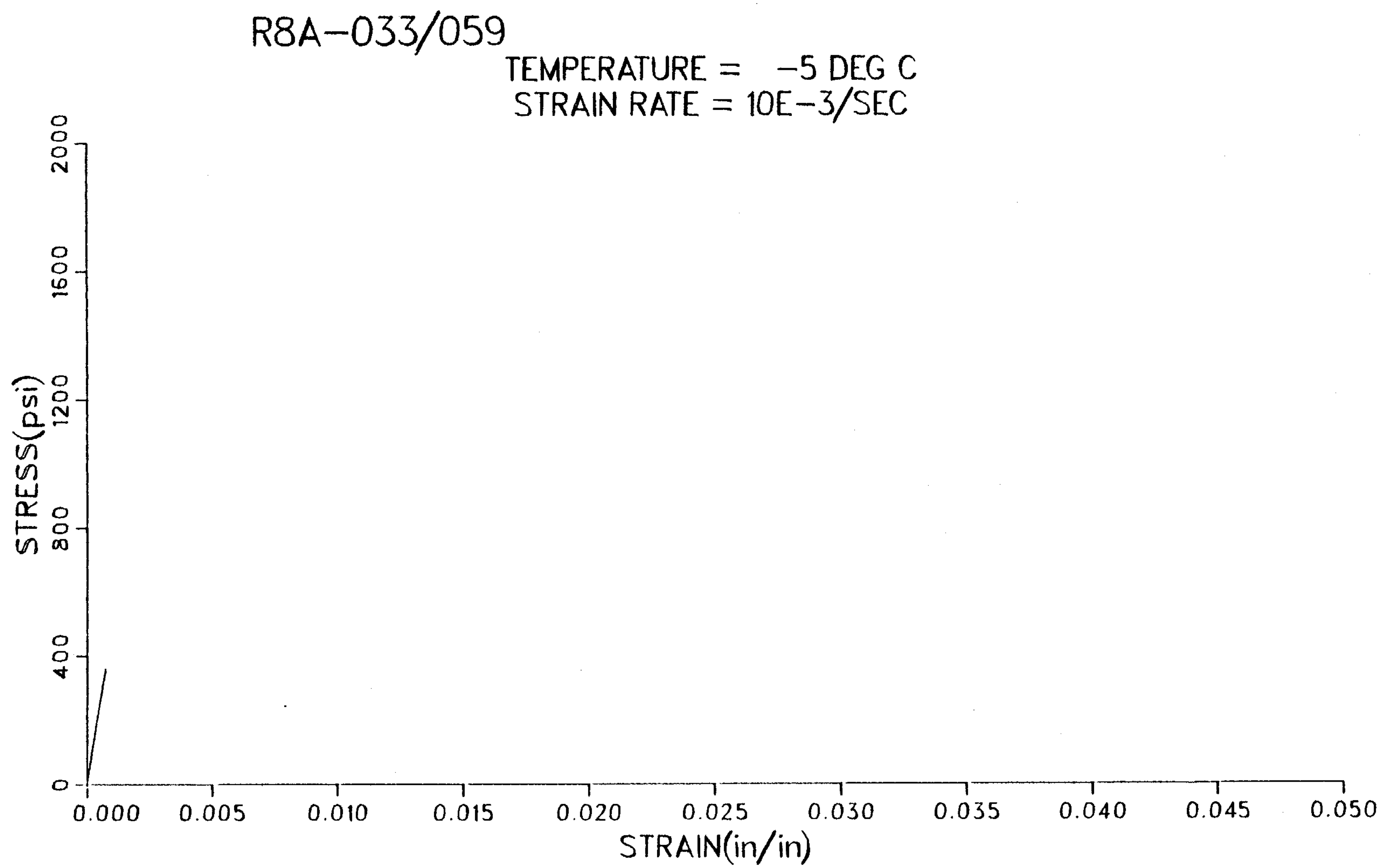

R4B-299/325
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

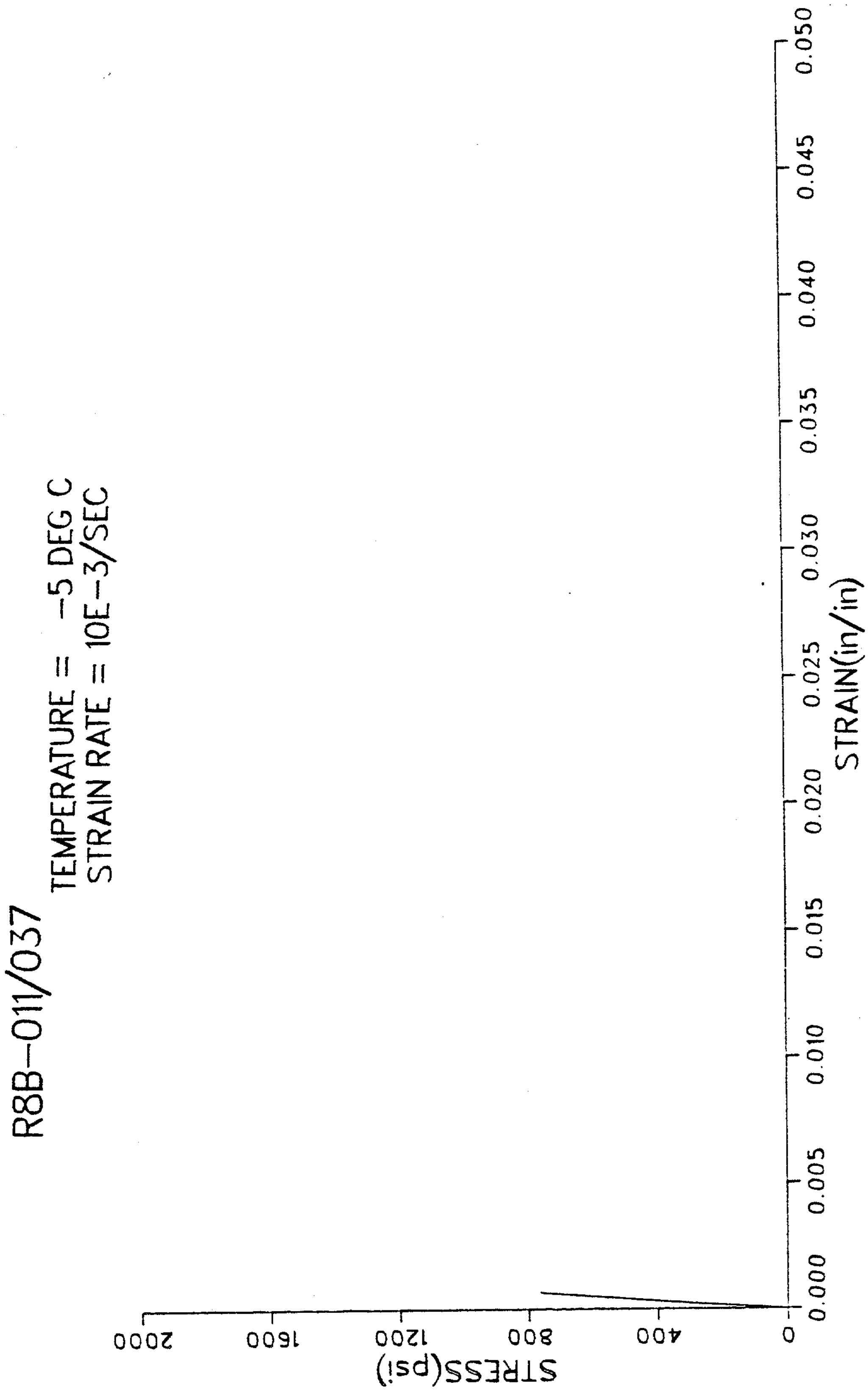

R5A-135/161
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

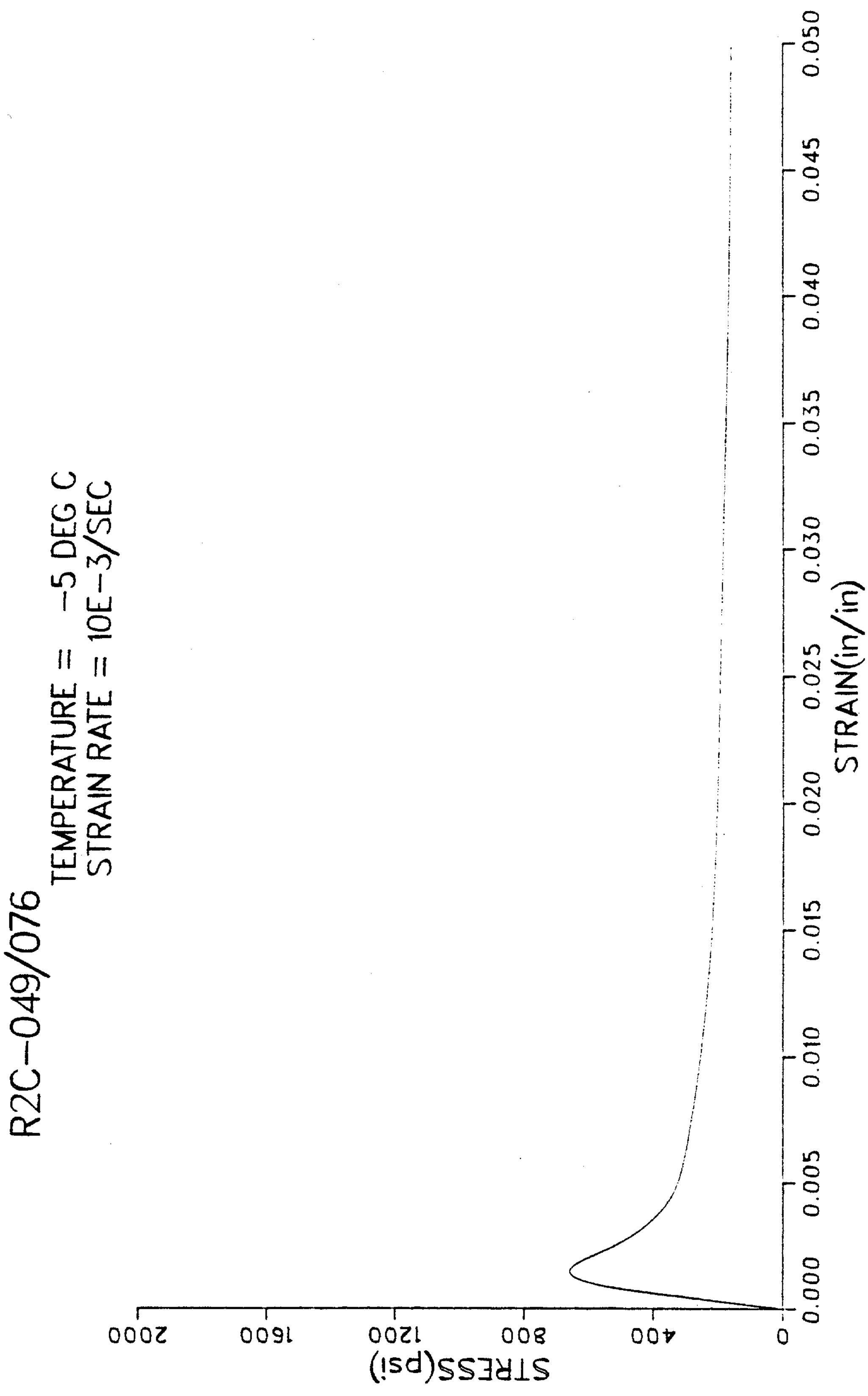

R5B–141/167
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–3/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000

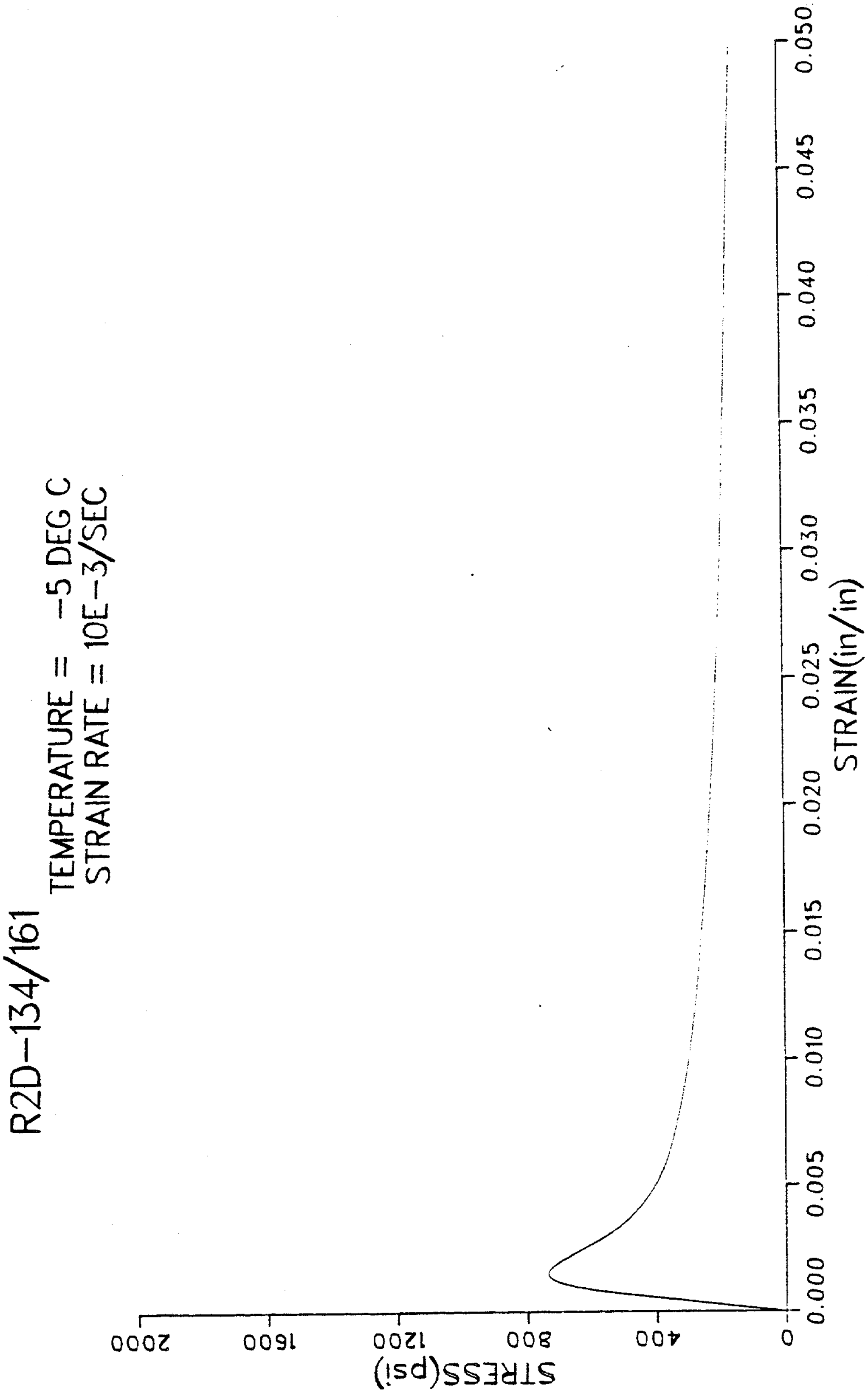

R7A-005/031
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

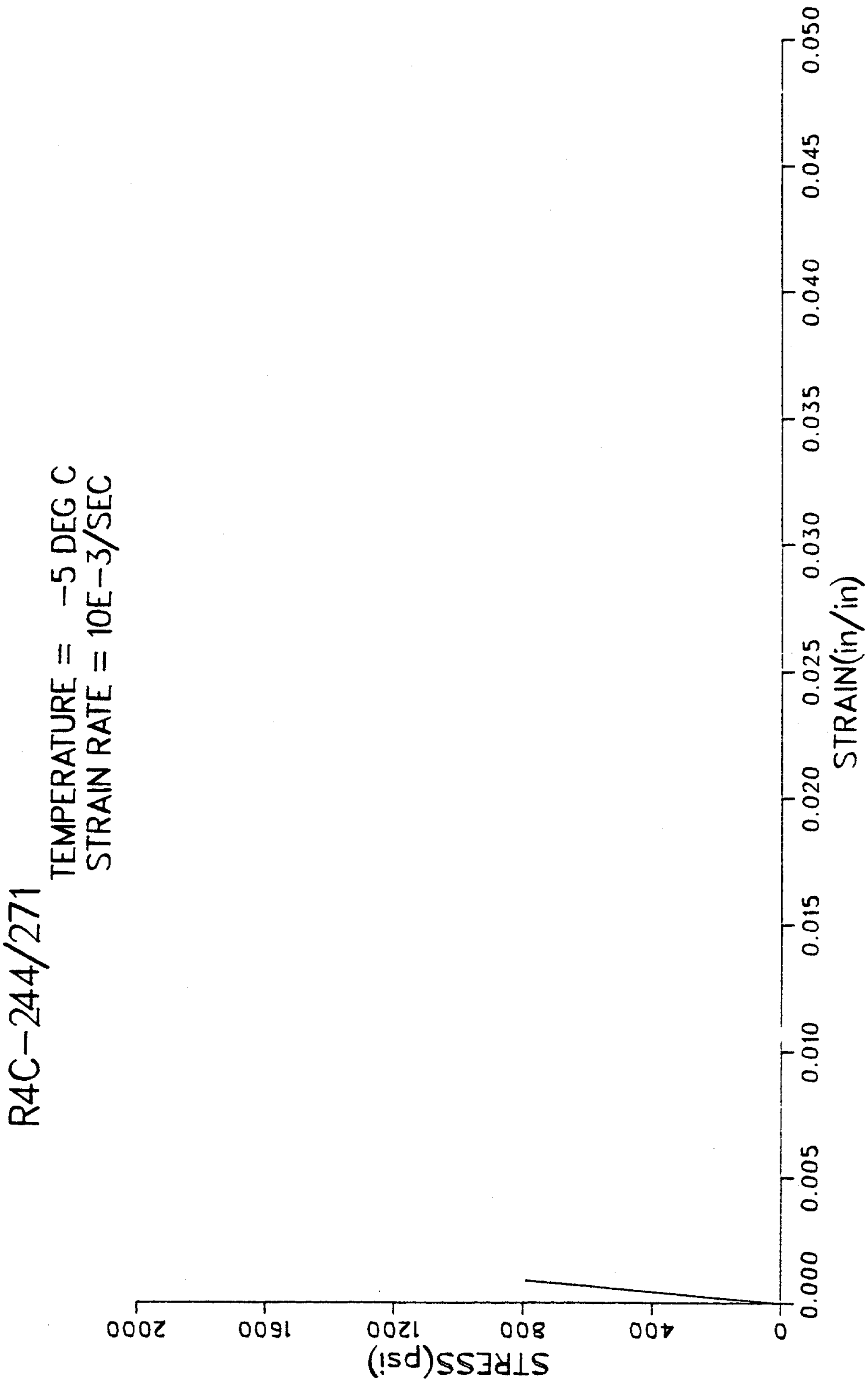

R7B-072/098
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

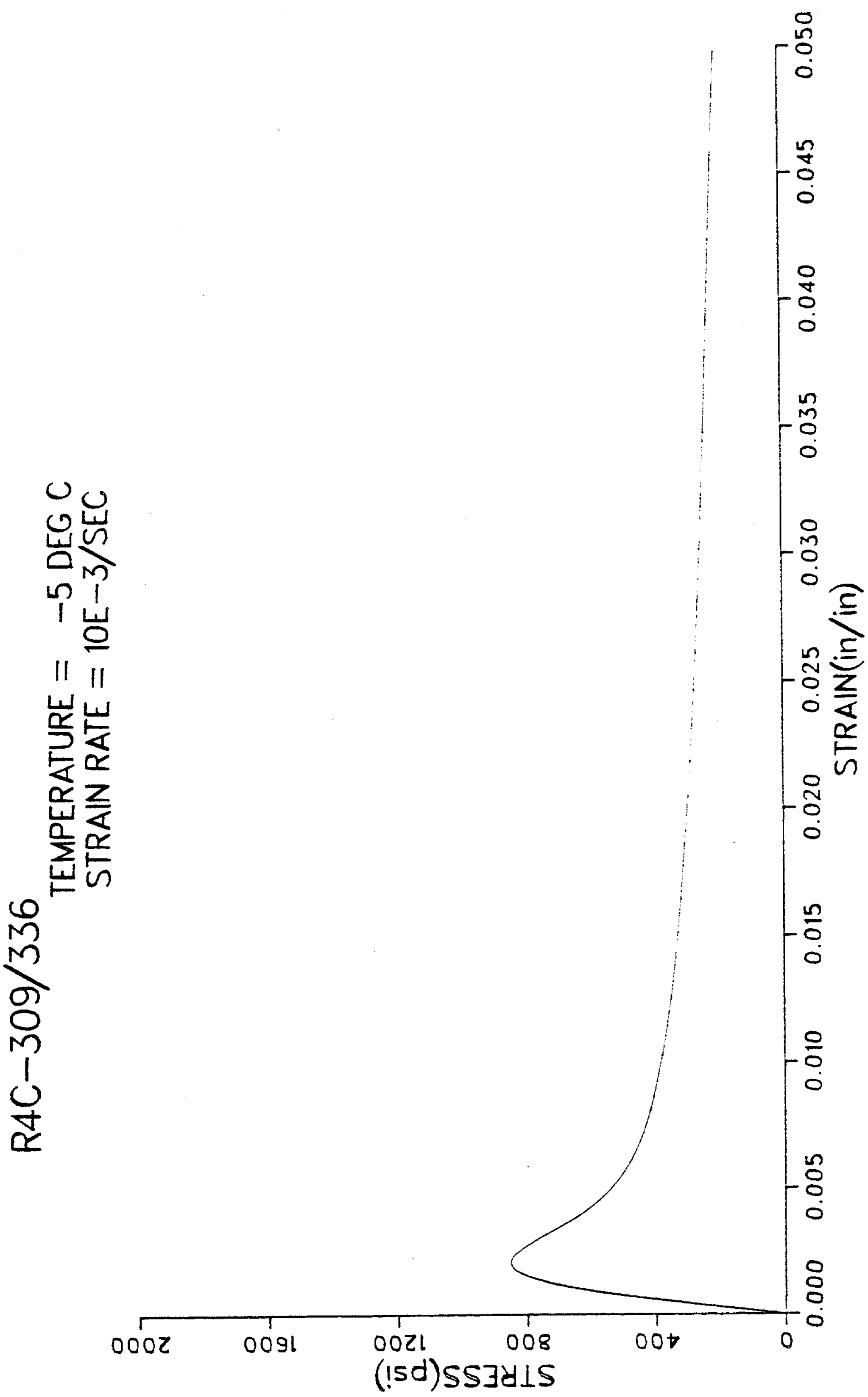

R8A-033/059
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRAIN(in/in)

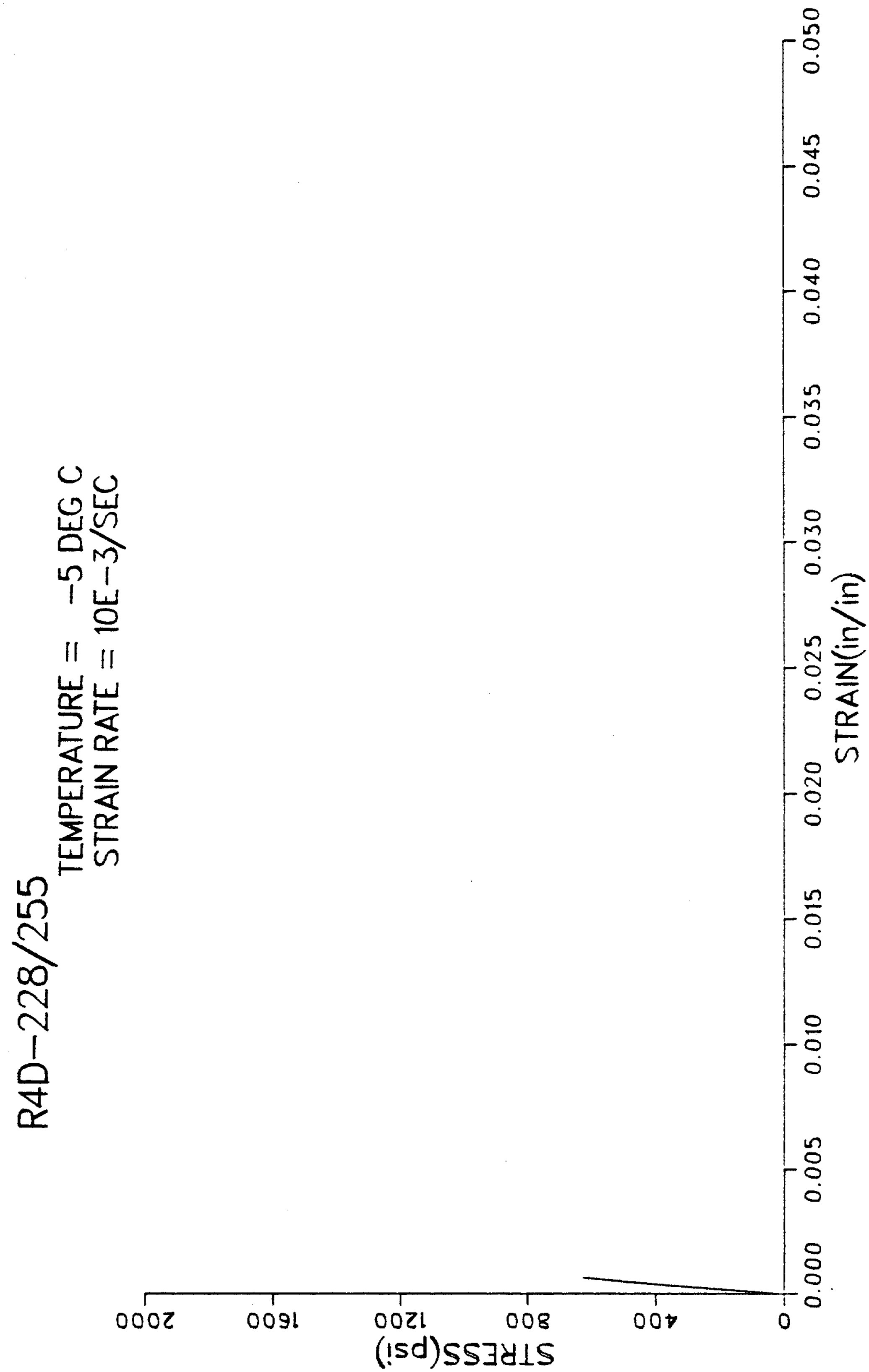

R8B-011/037
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRAIN(in/in)
0
400
800
1200
1600
2000
STRESS(psi)

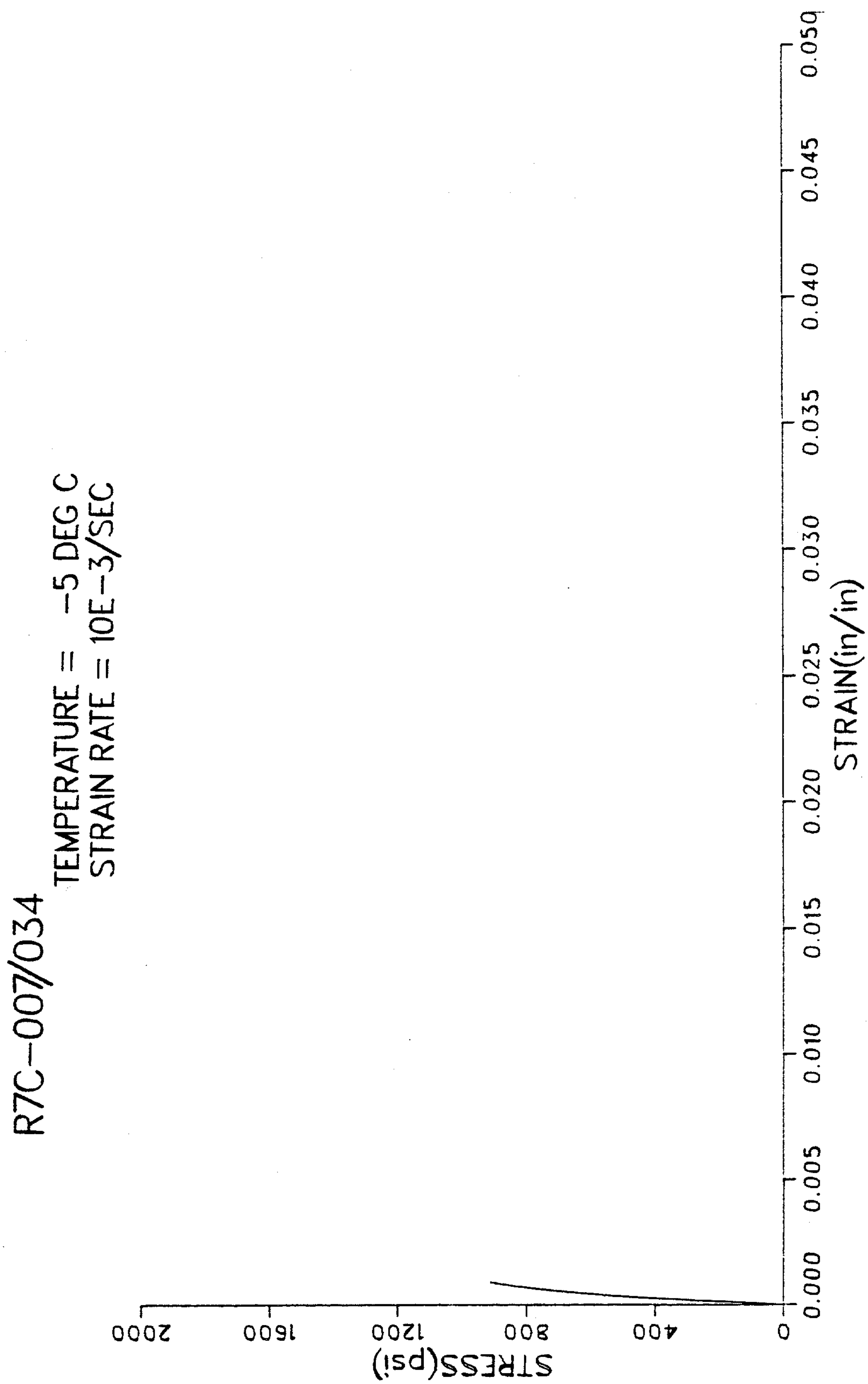

R2C-049/076
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

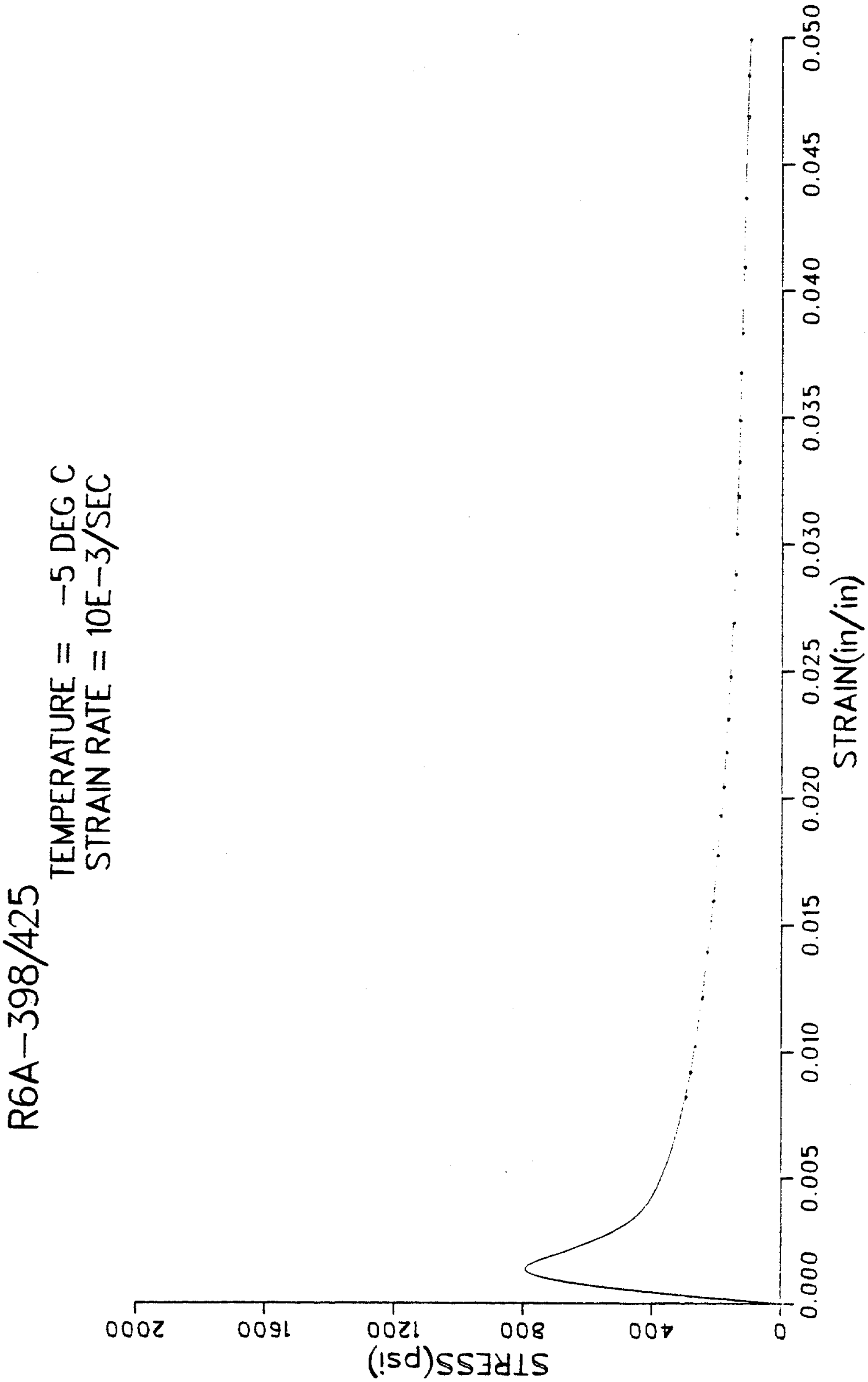

R2D-134/161
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

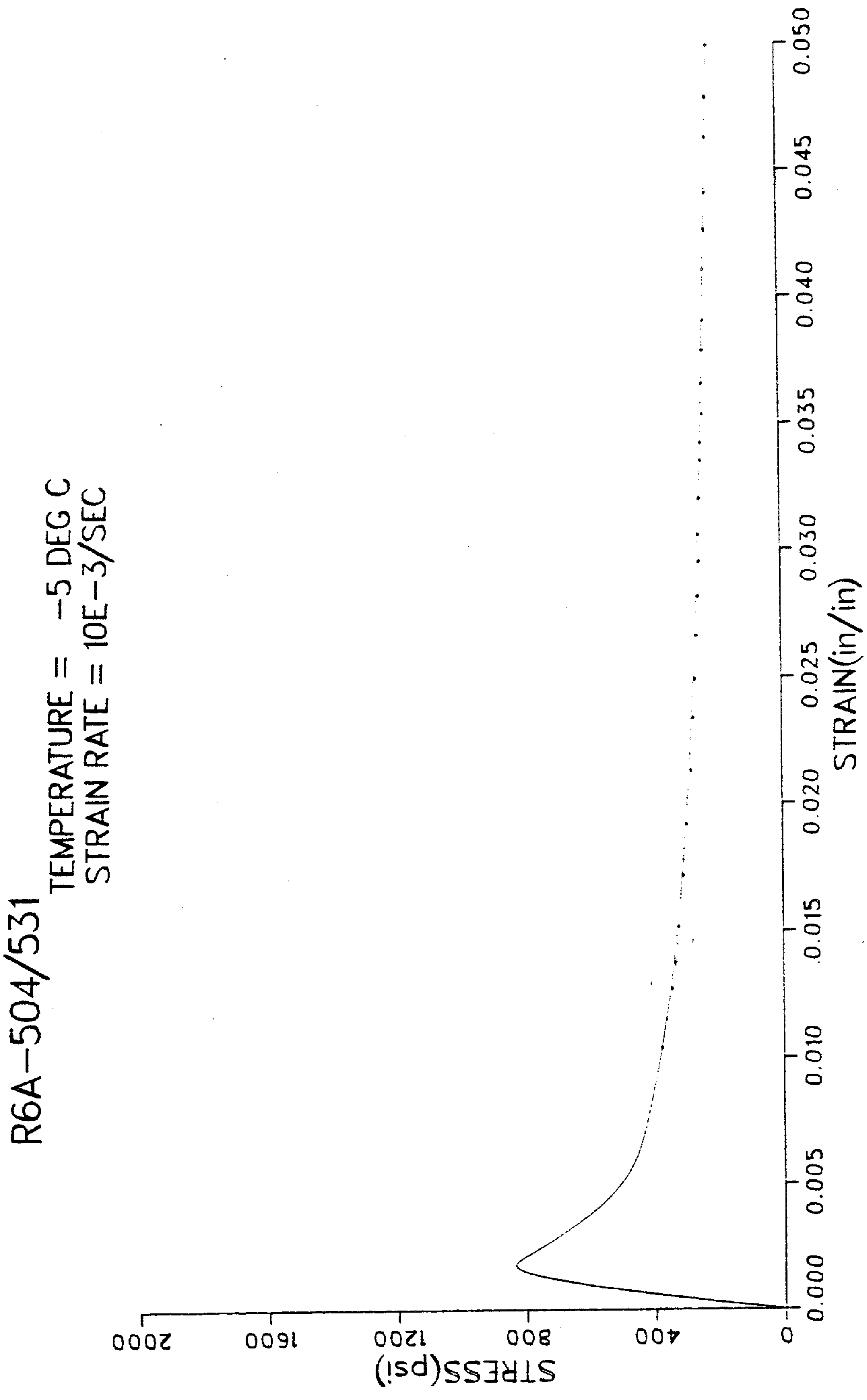

R4C-244/271
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000

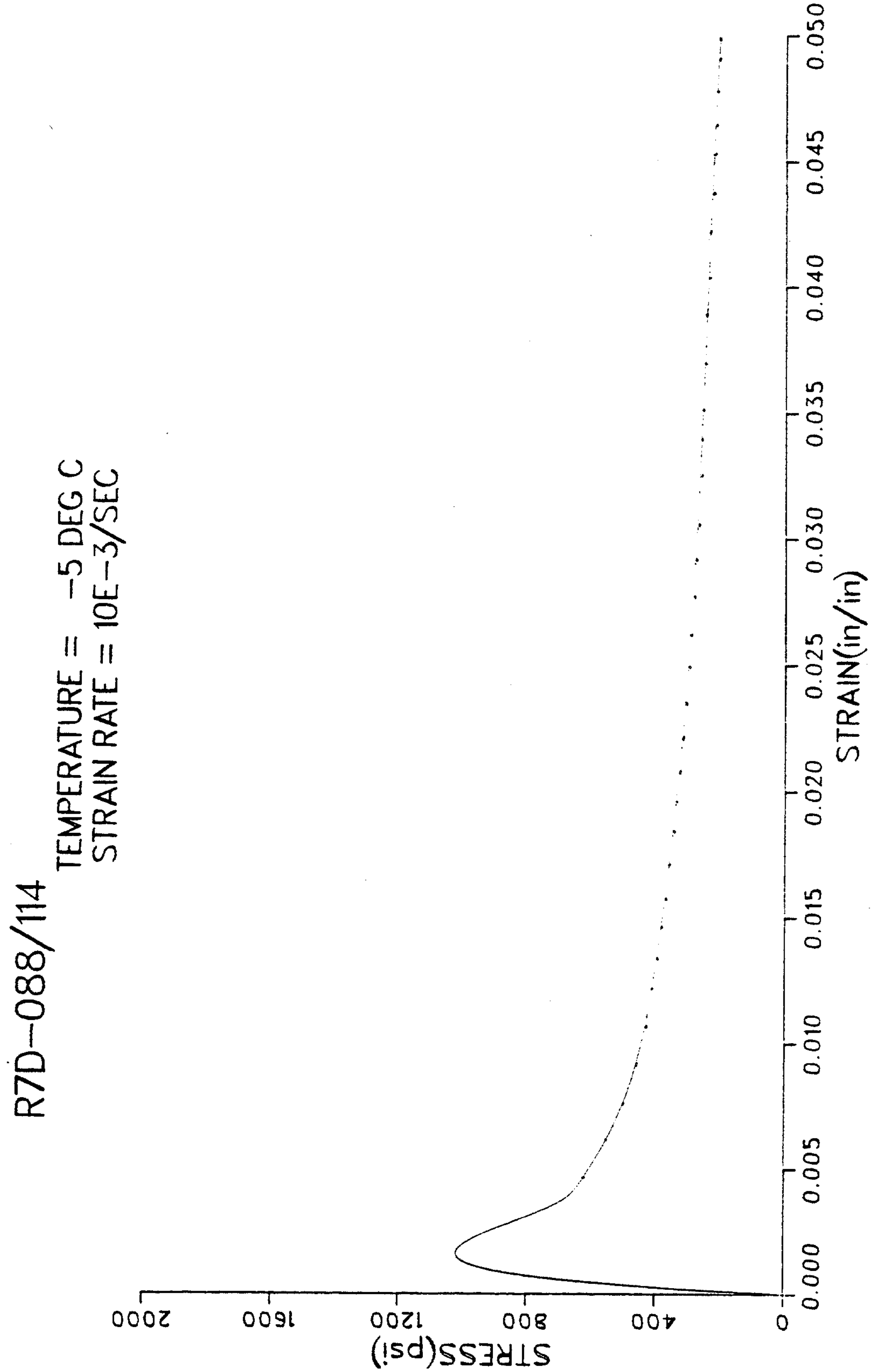

R4C-309/336
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000

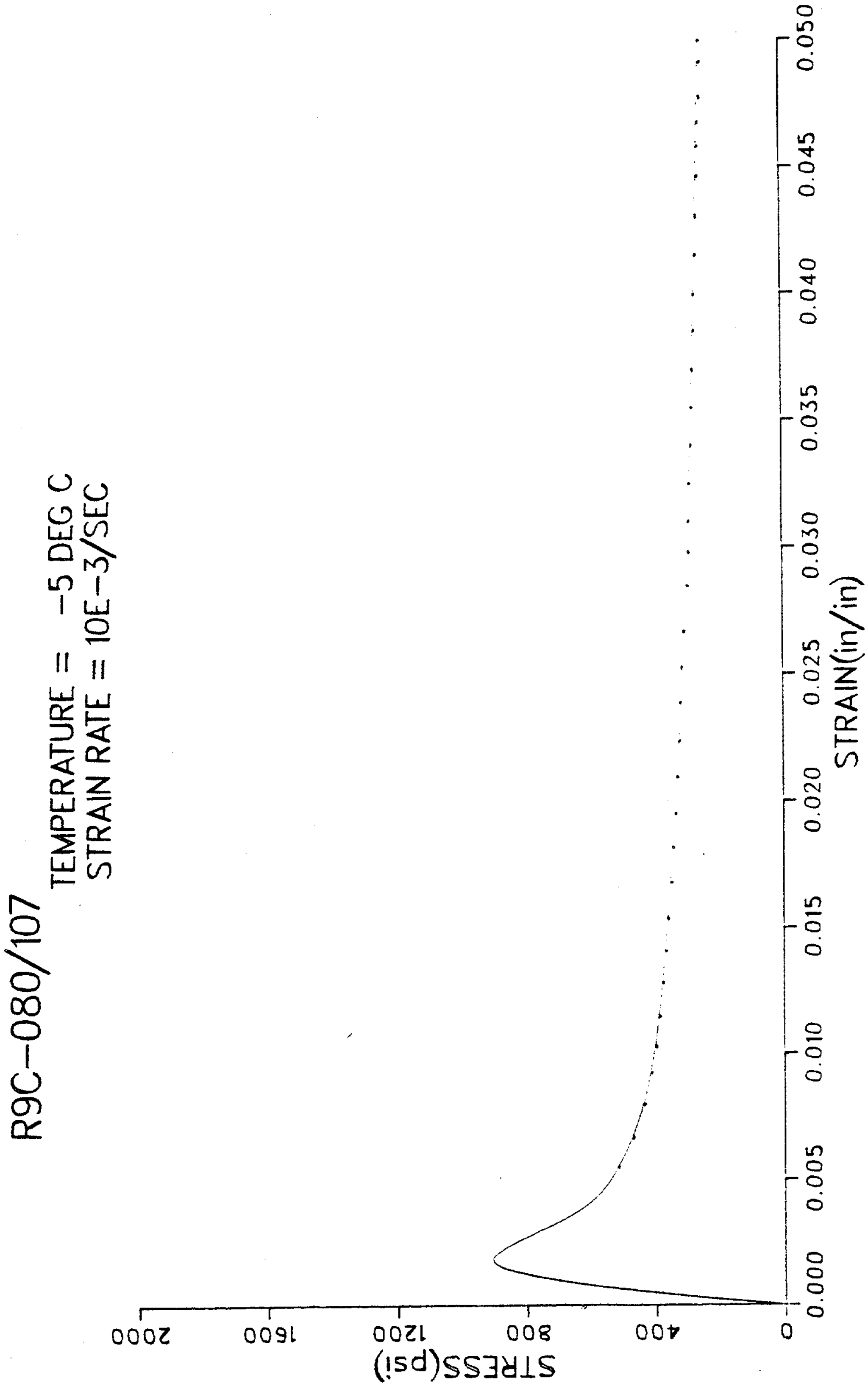

R4D-228/255
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

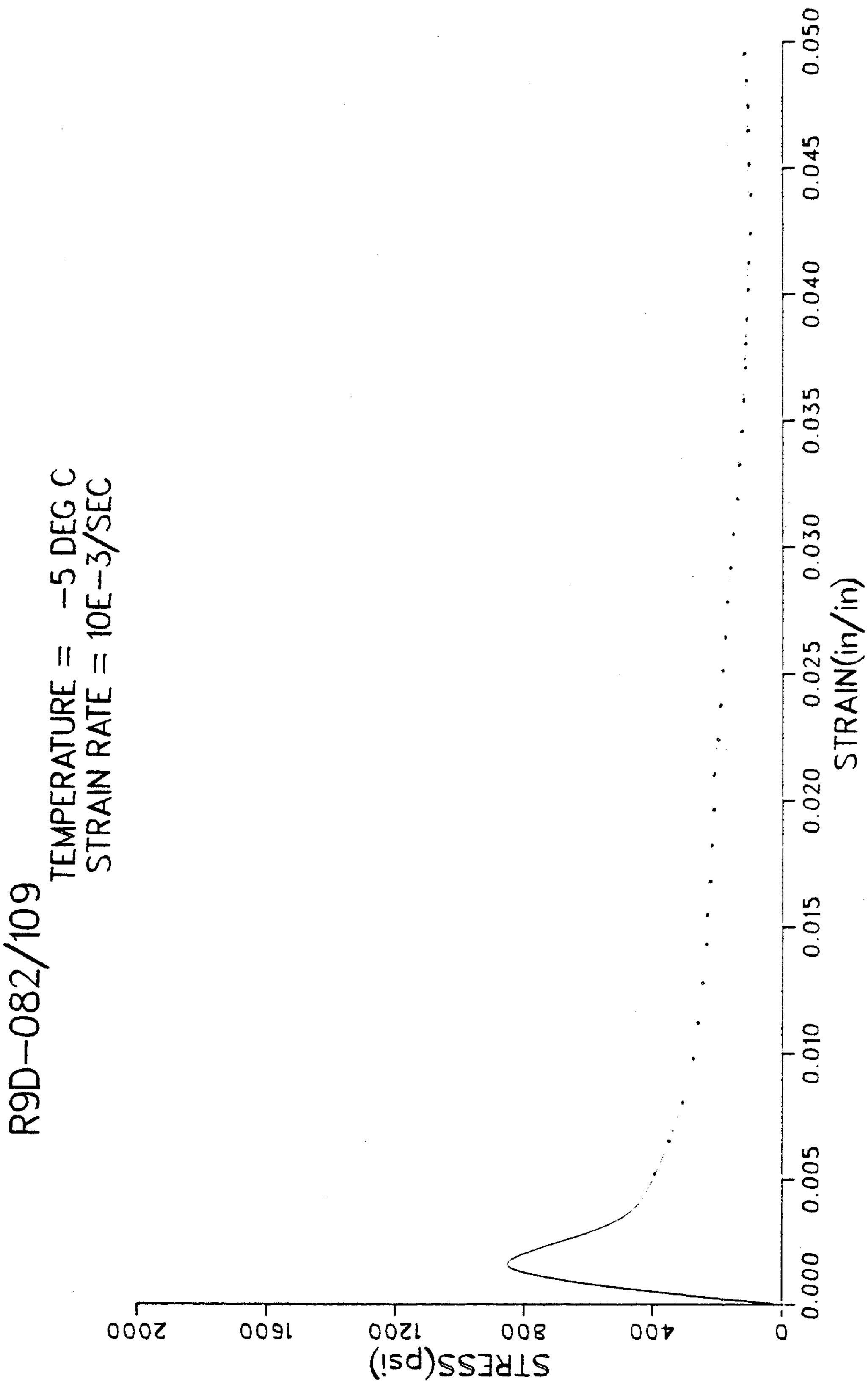

R7C–007/034
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

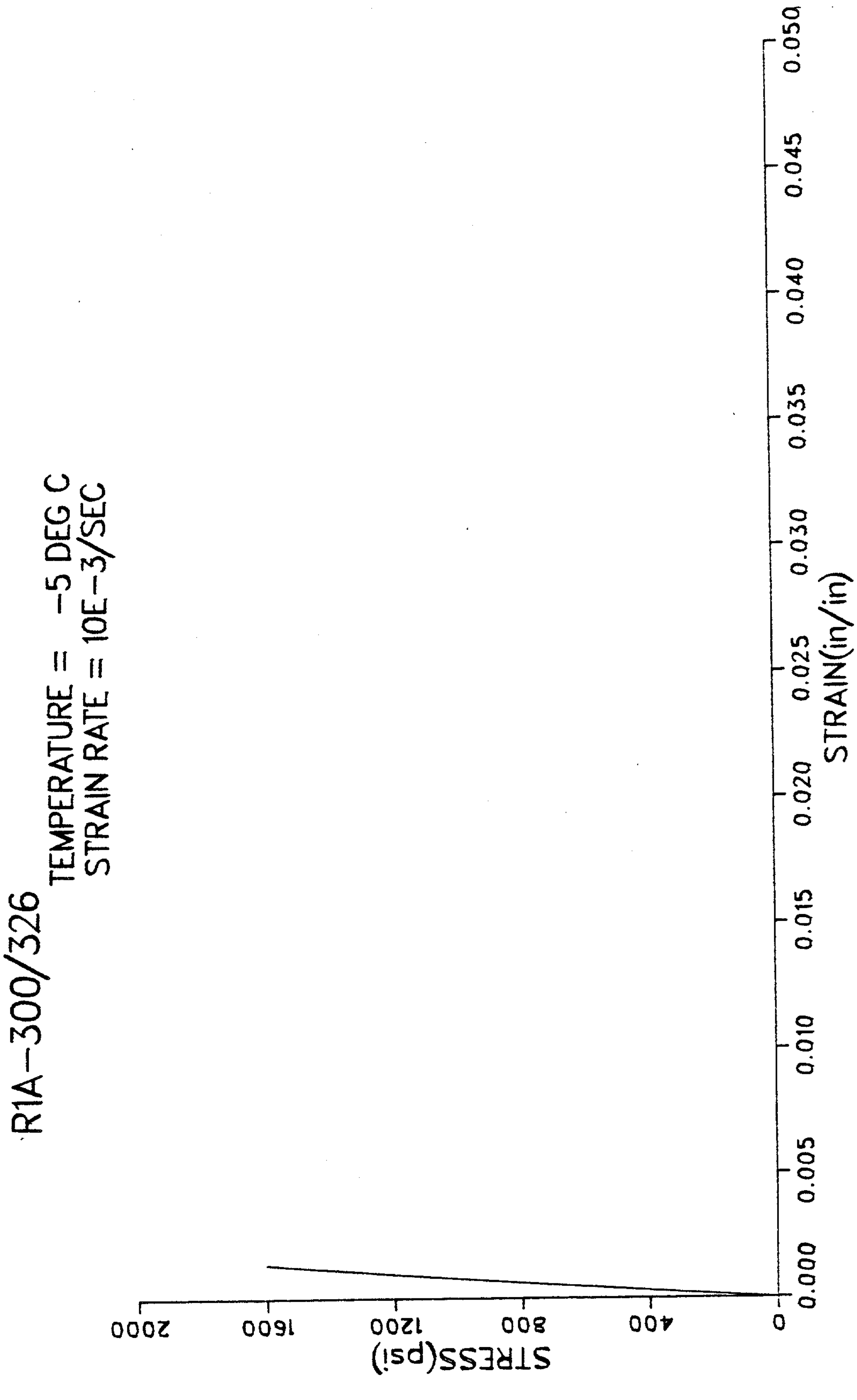

R6A—398/425
TEMPERATURE = −5 DEG C
STRAIN RATE = 10E−3/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
400
800
1200
1600
2000

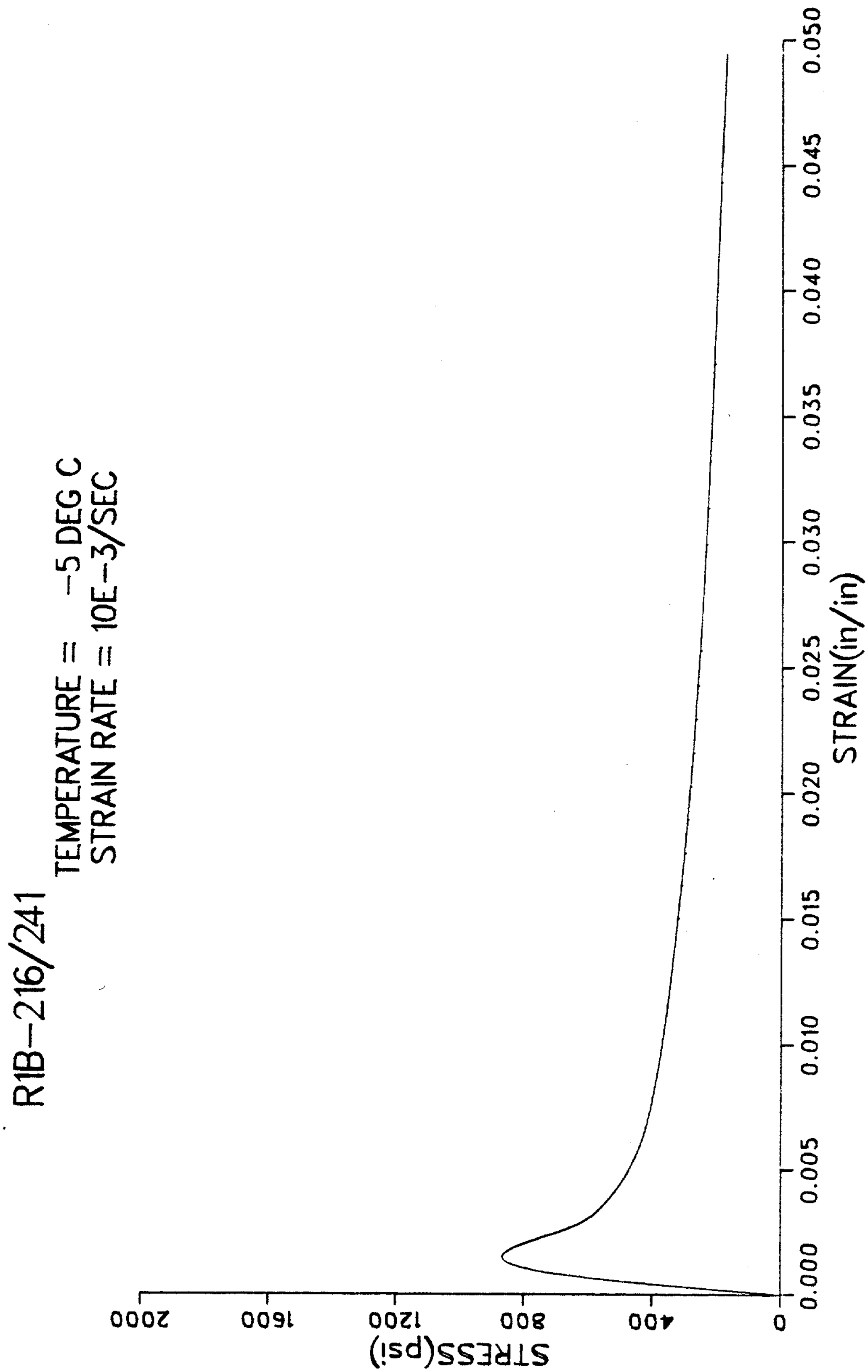

R6A-504/531
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

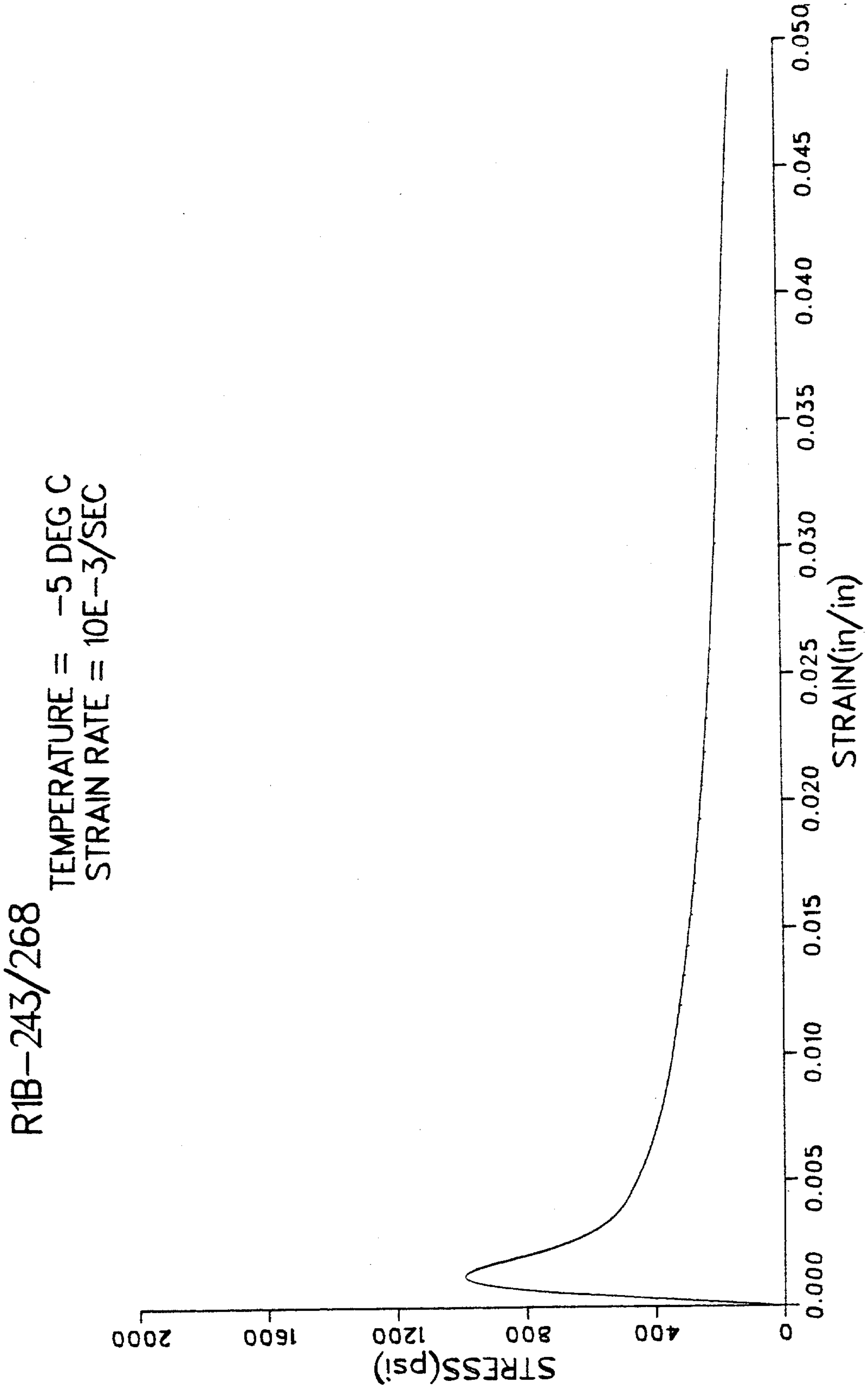

R7D-088/114
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

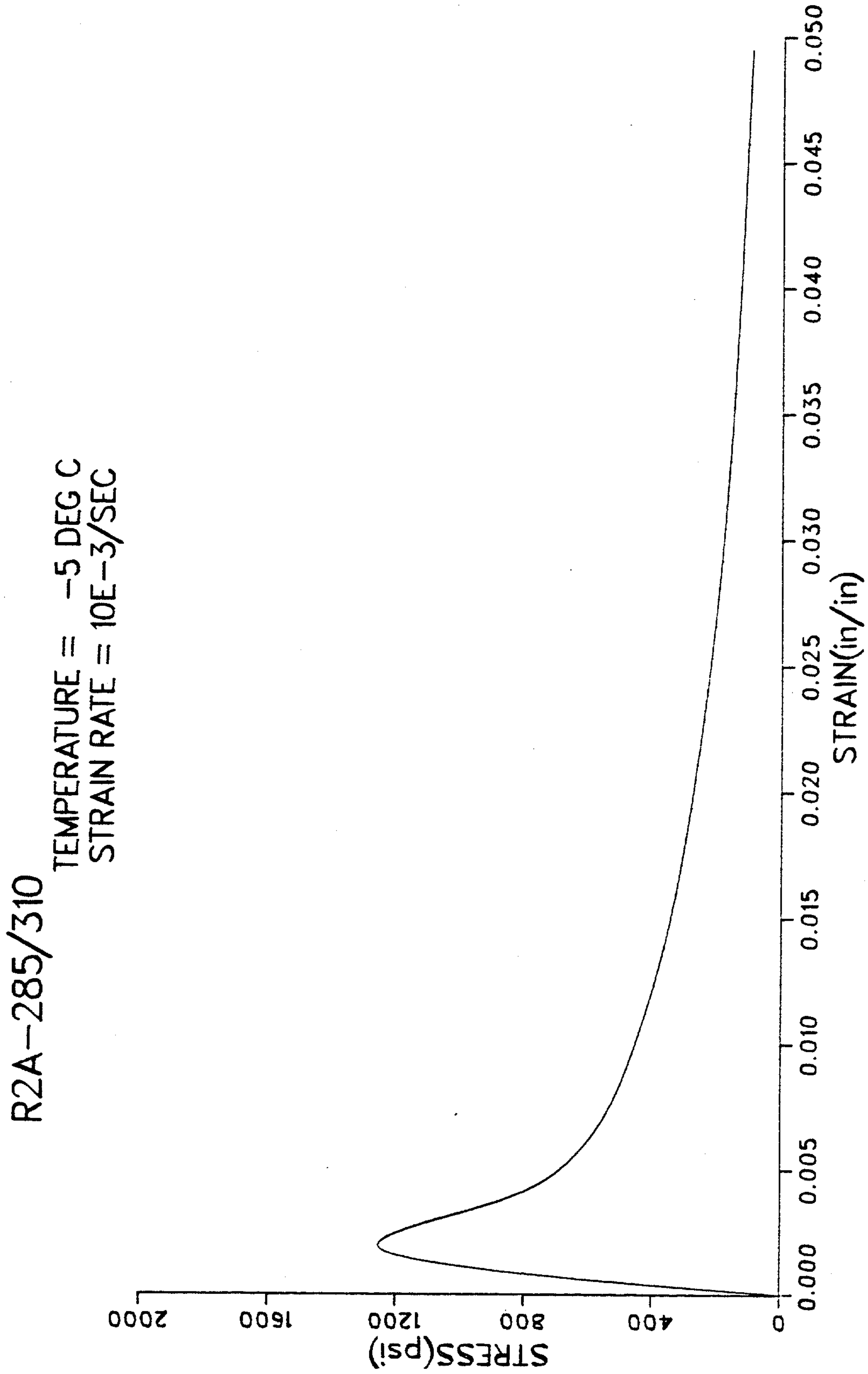

R9C-080/107
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000

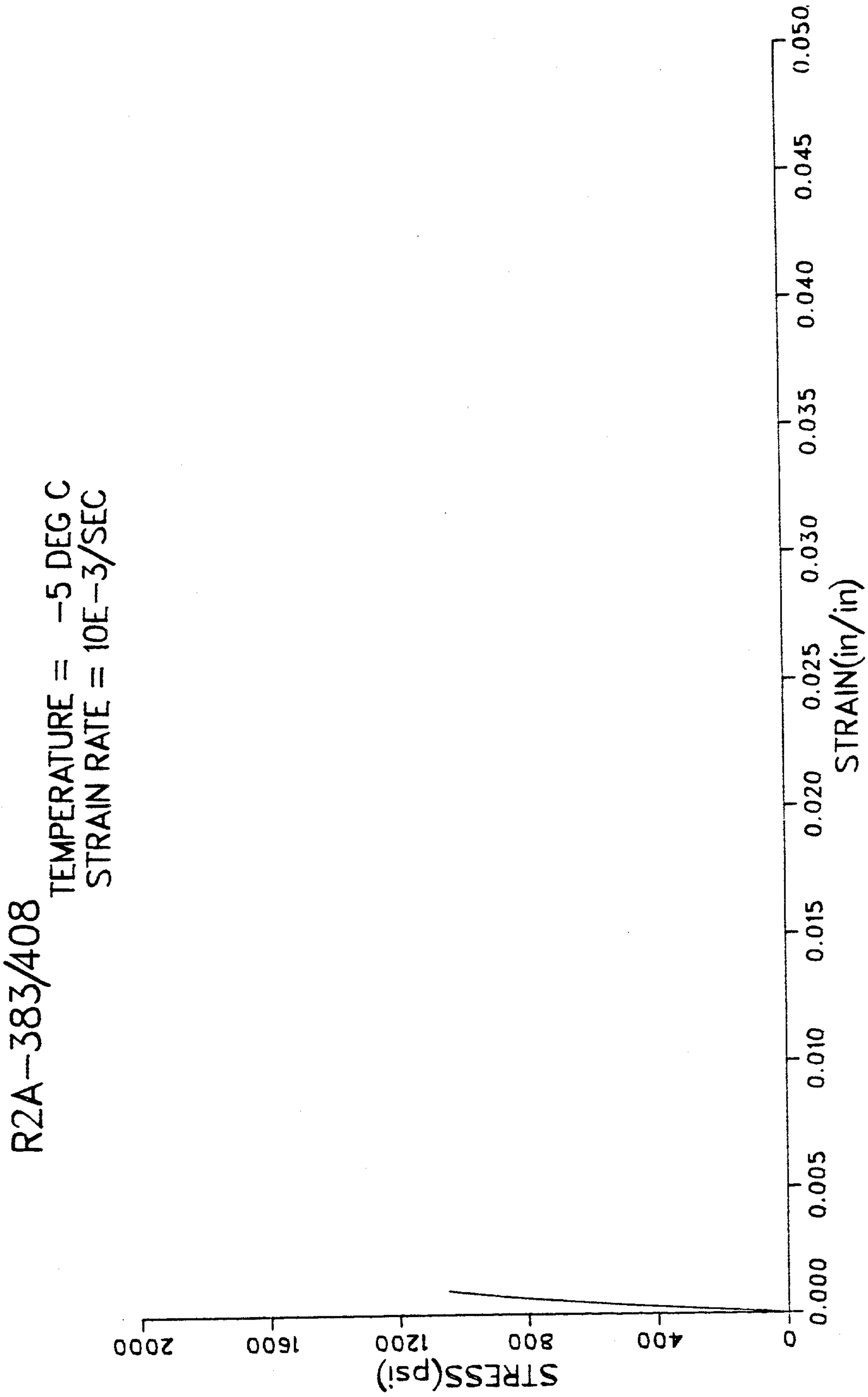

R9D-082/109
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

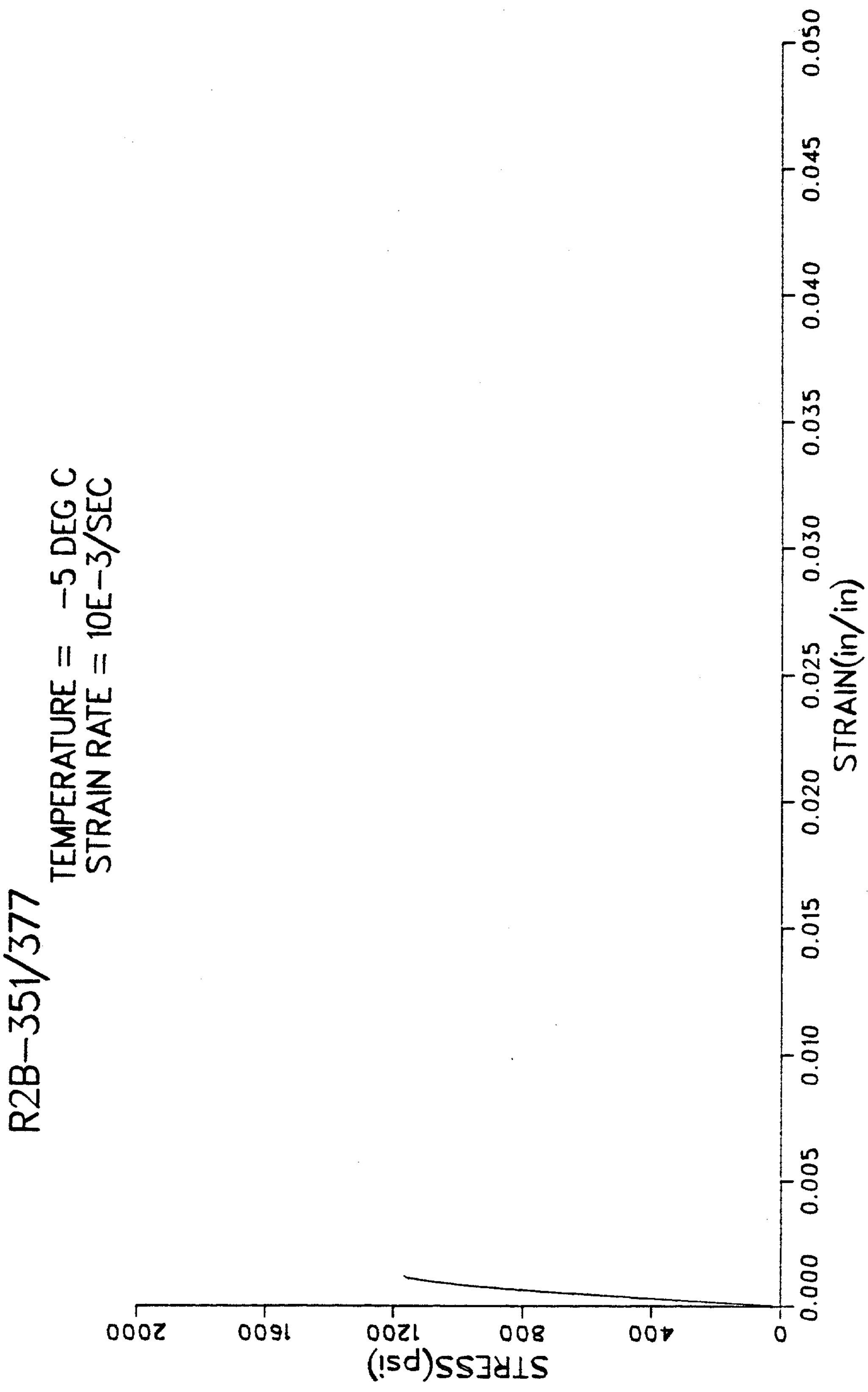

R1A-300/326
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

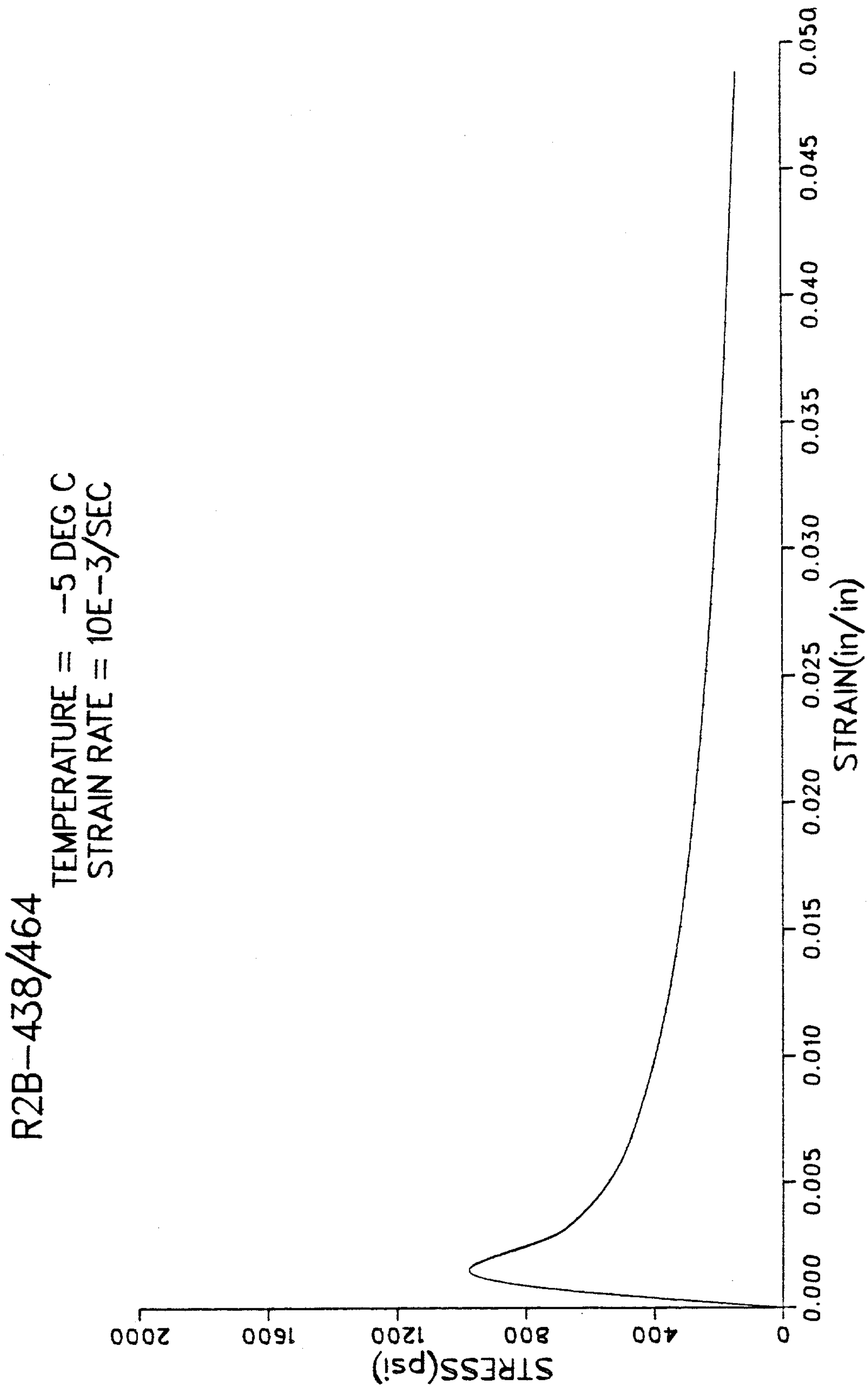

R1B–216/241
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

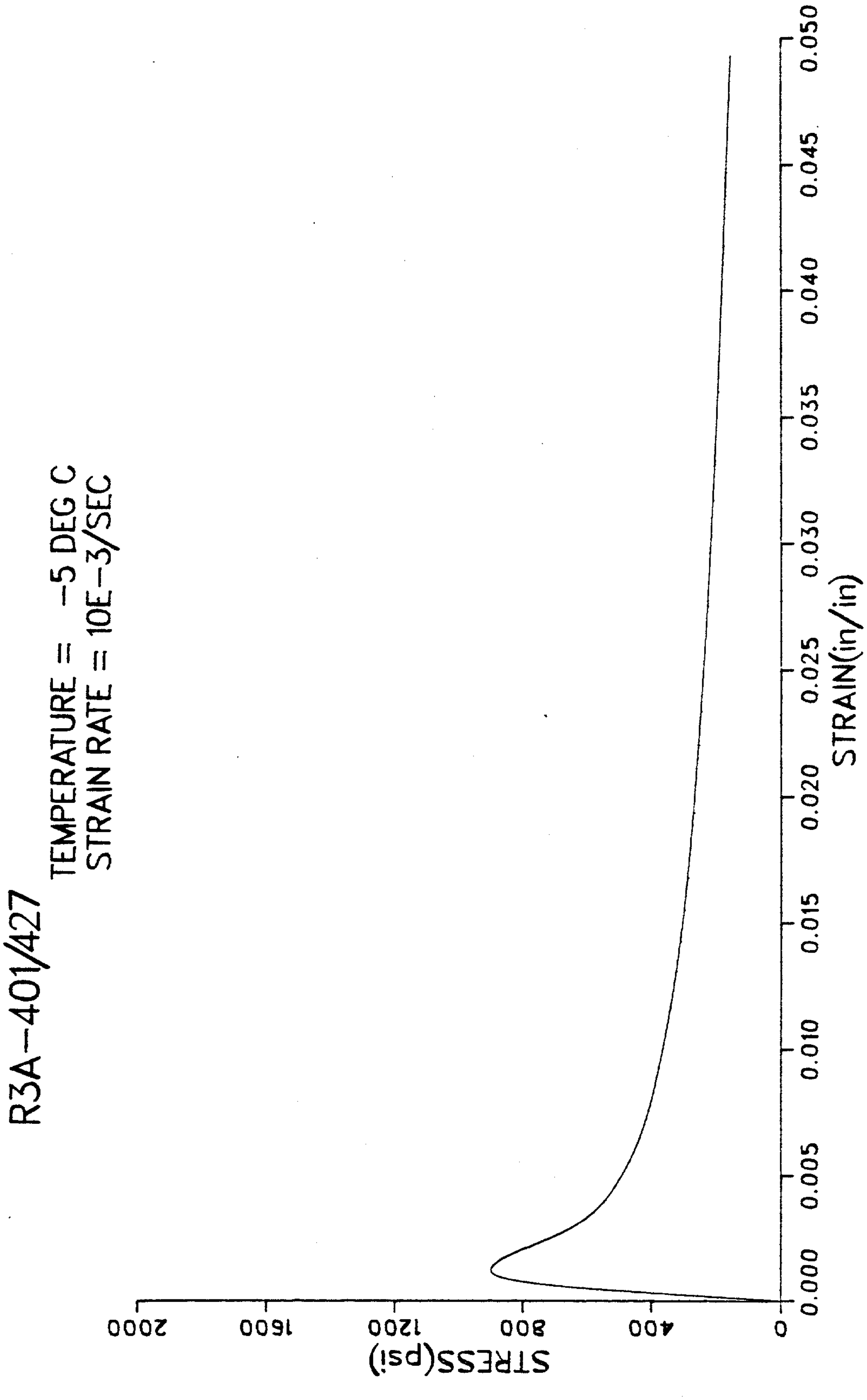

R1B—243/268
TEMPERATURE = —5 DEG C
STRAIN RATE = 10E—3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

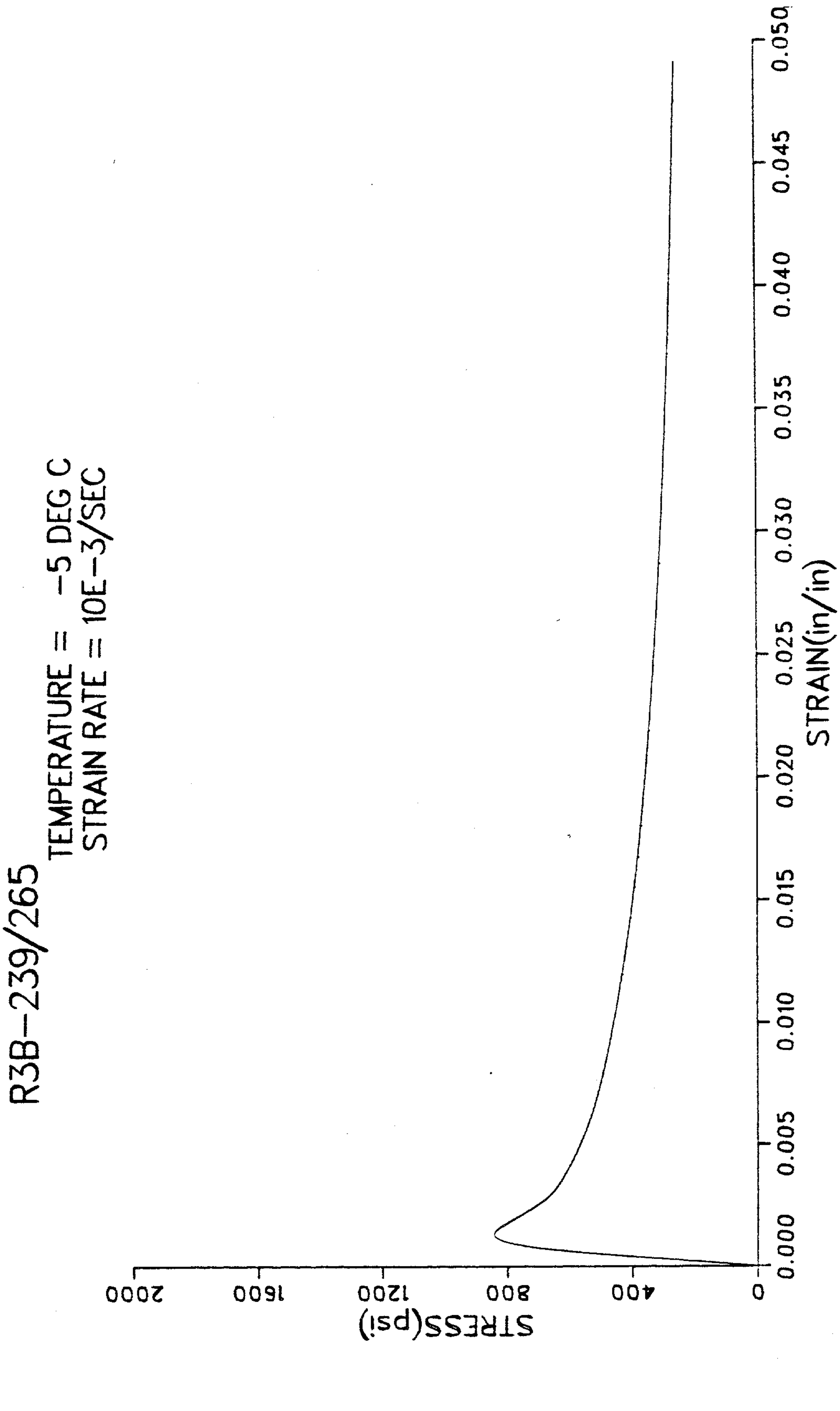

R2A-285/310
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

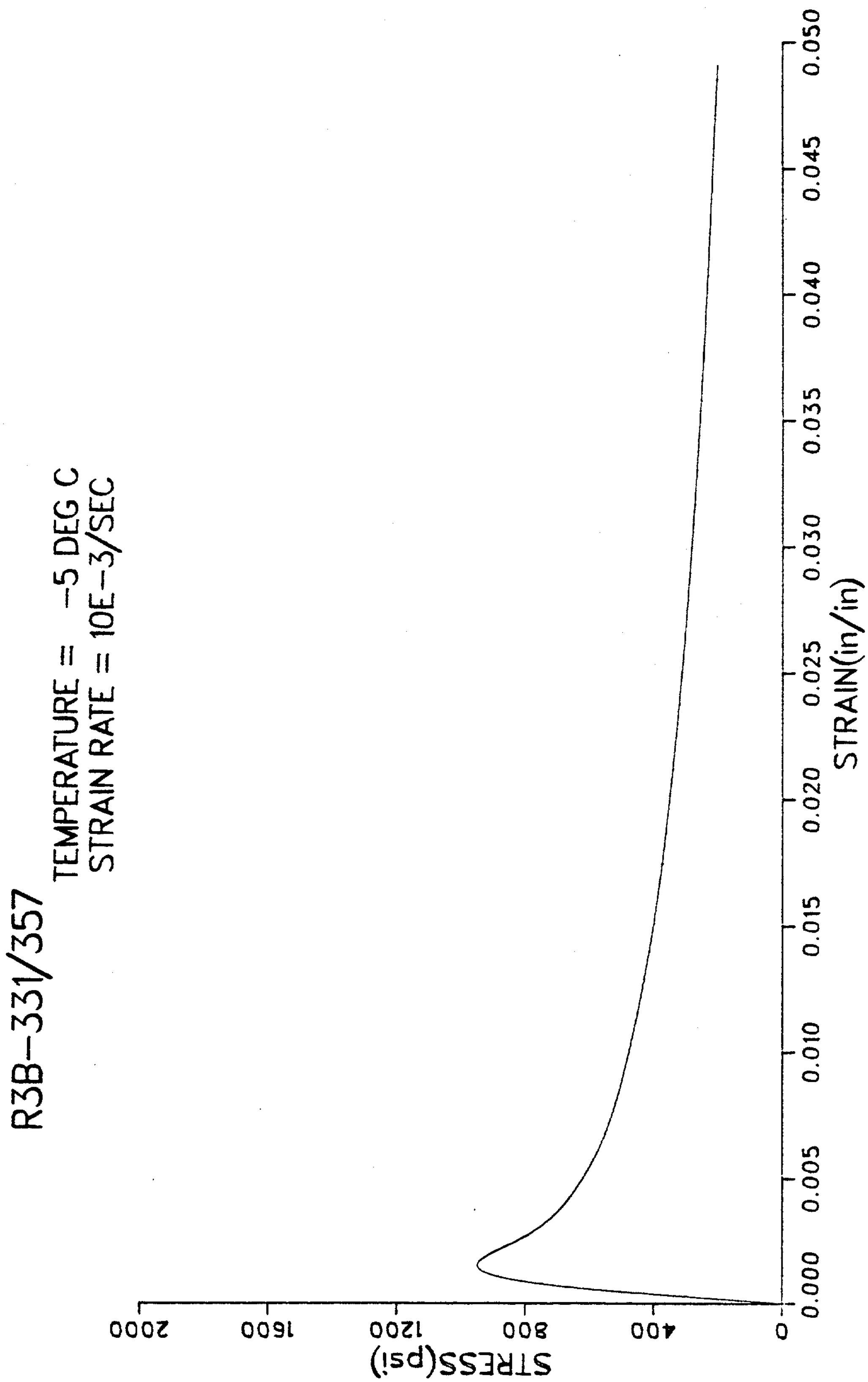

R2A−383/408
TEMPERATURE = −5 DEG C
STRAIN RATE = 10E−3/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000

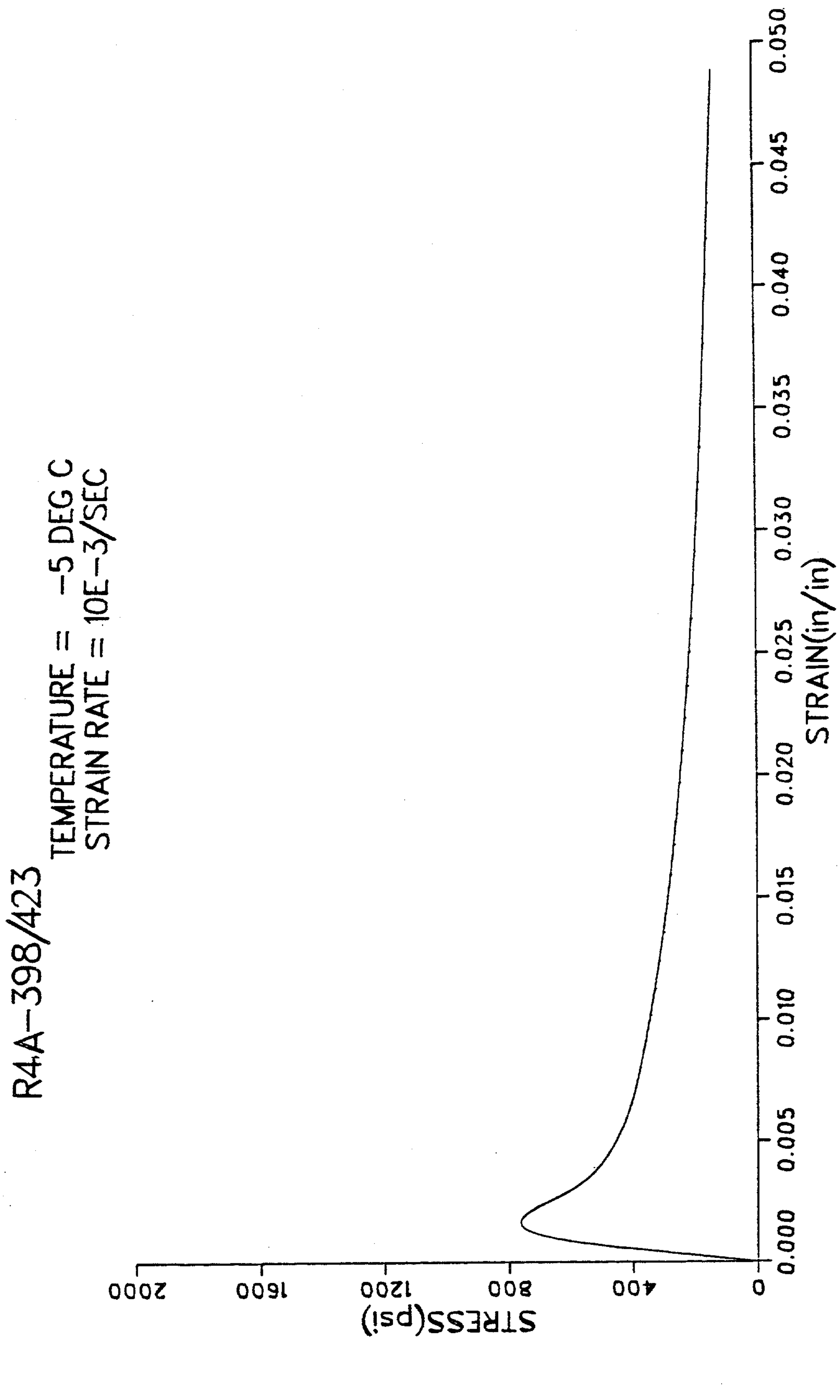

R2B—351/377
TEMPERATURE = −5 DEG C
STRAIN RATE = 10E−3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

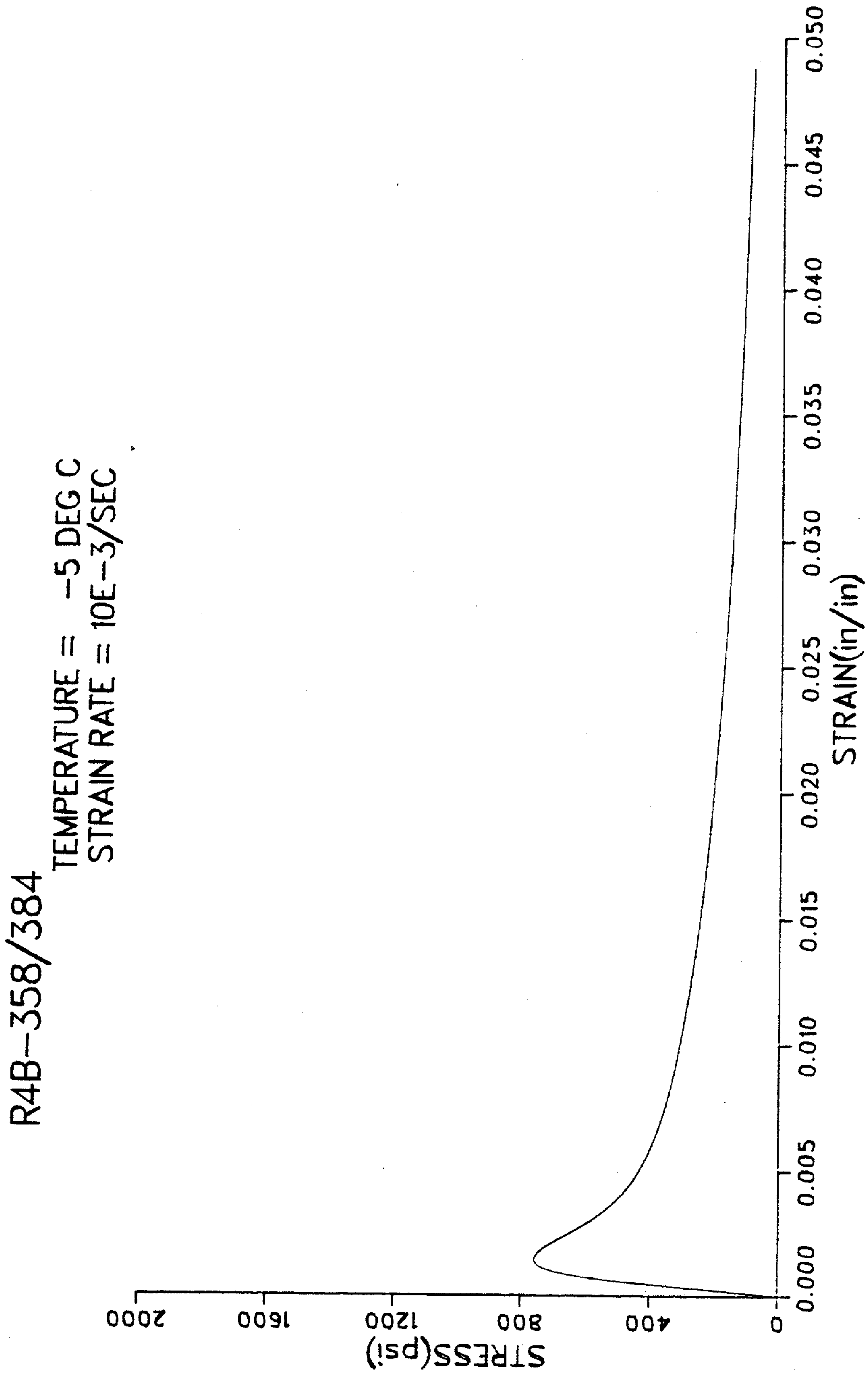

R2B-438/464
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000

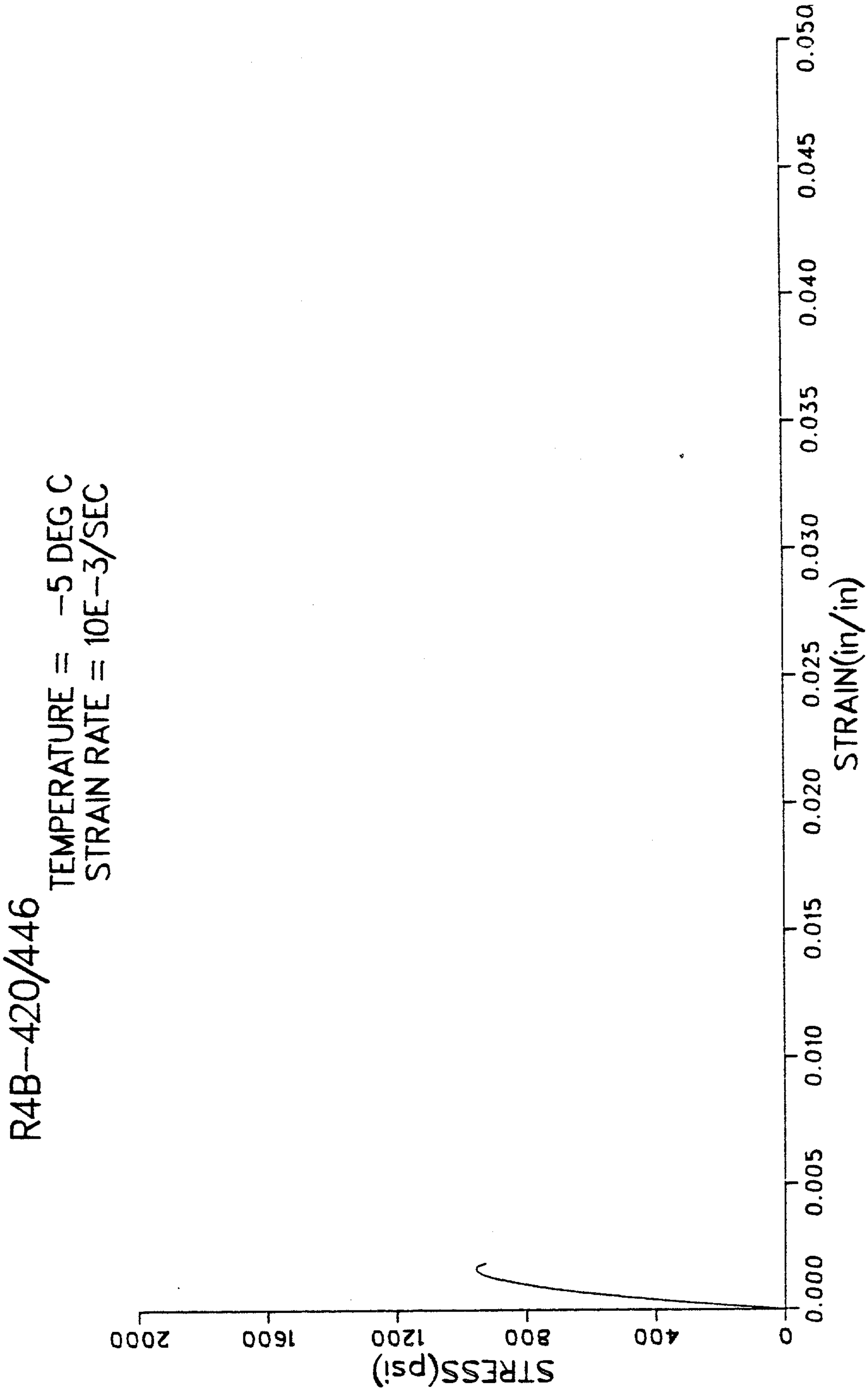

R3A-401/427
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

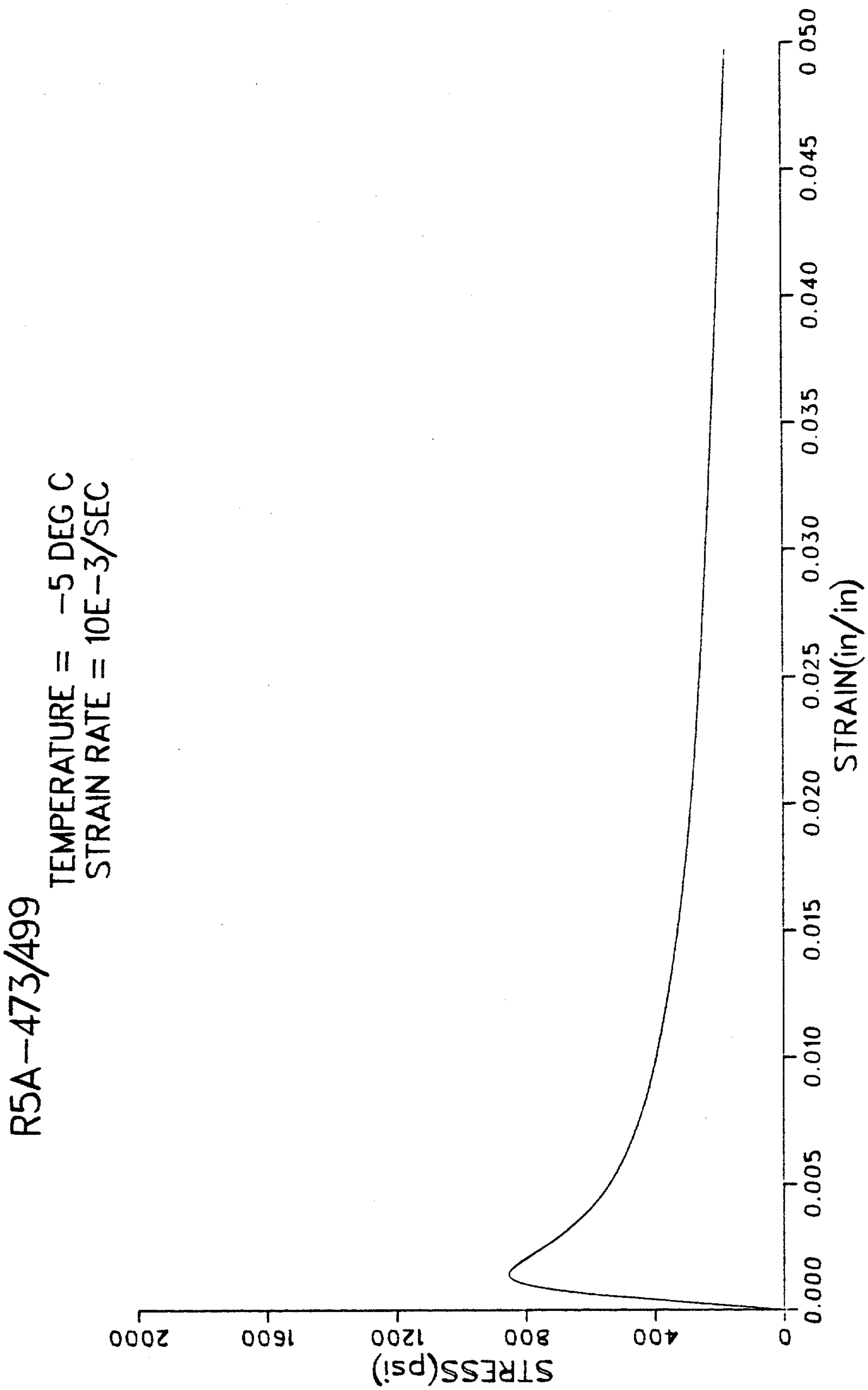

R3B–239/265
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

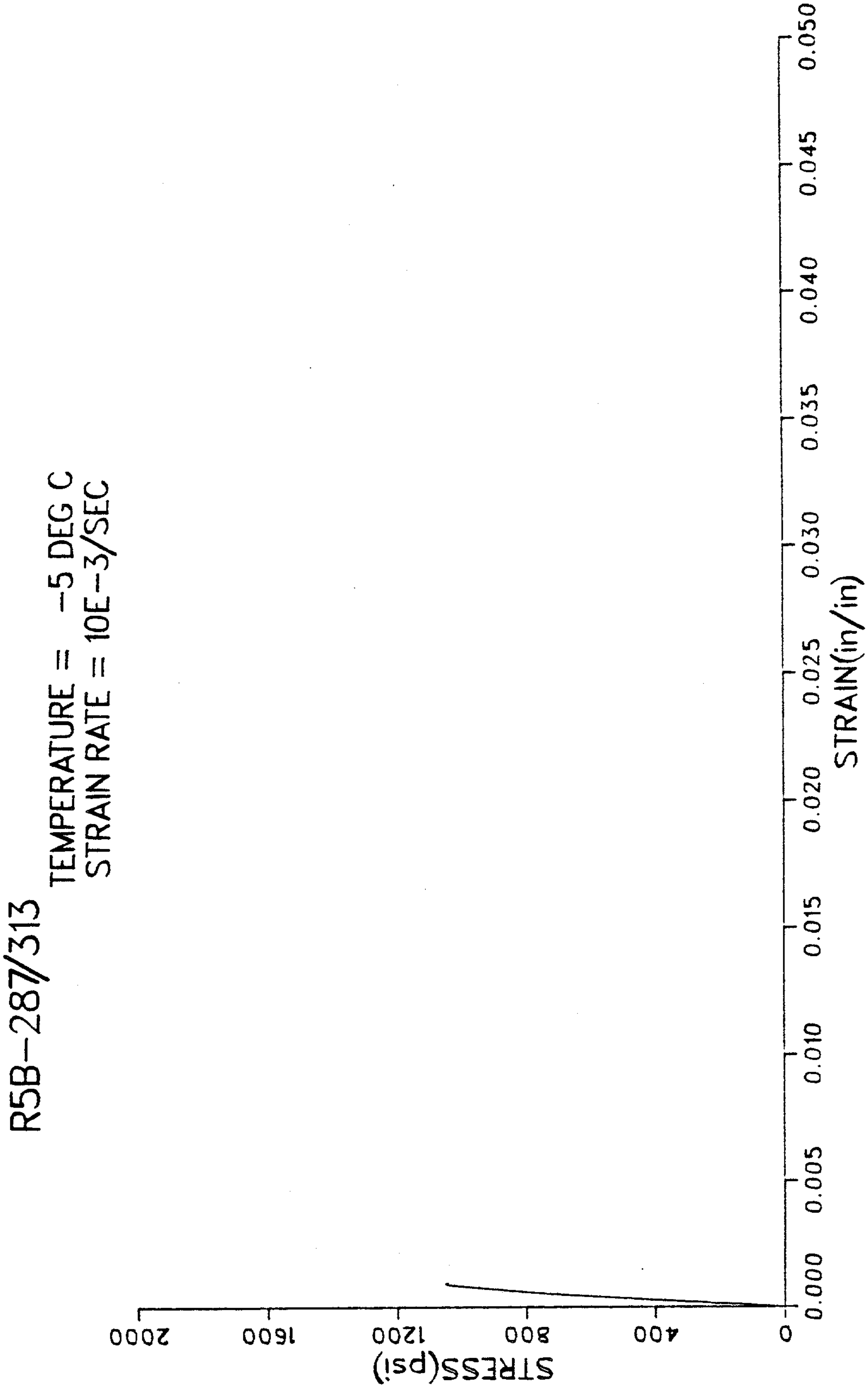

R3B–331/357
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–3/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
400
800
1200
1600
2000

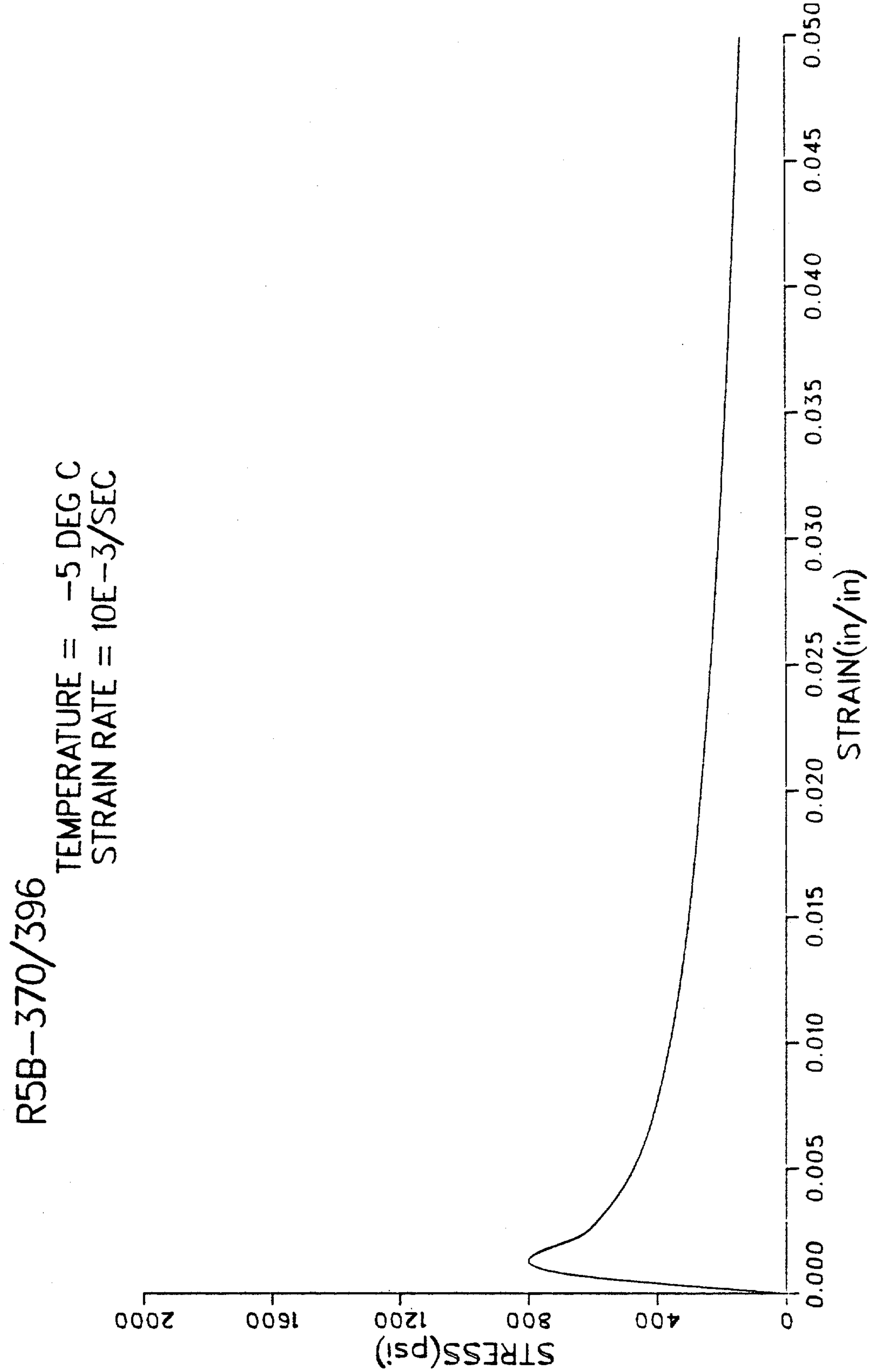

R4A-398/423
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
400
800
1200
1600
2000

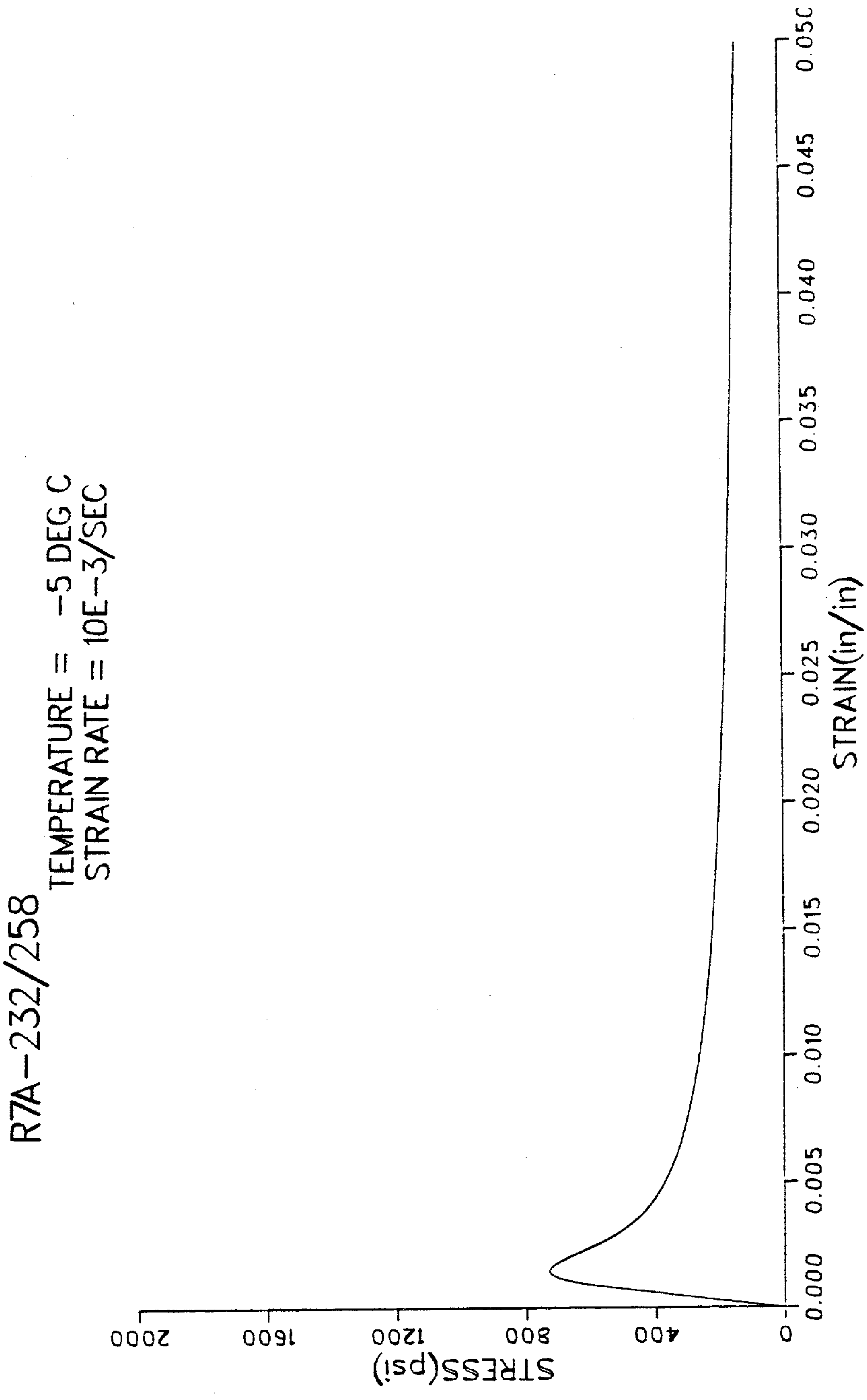

R4B-358/384
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

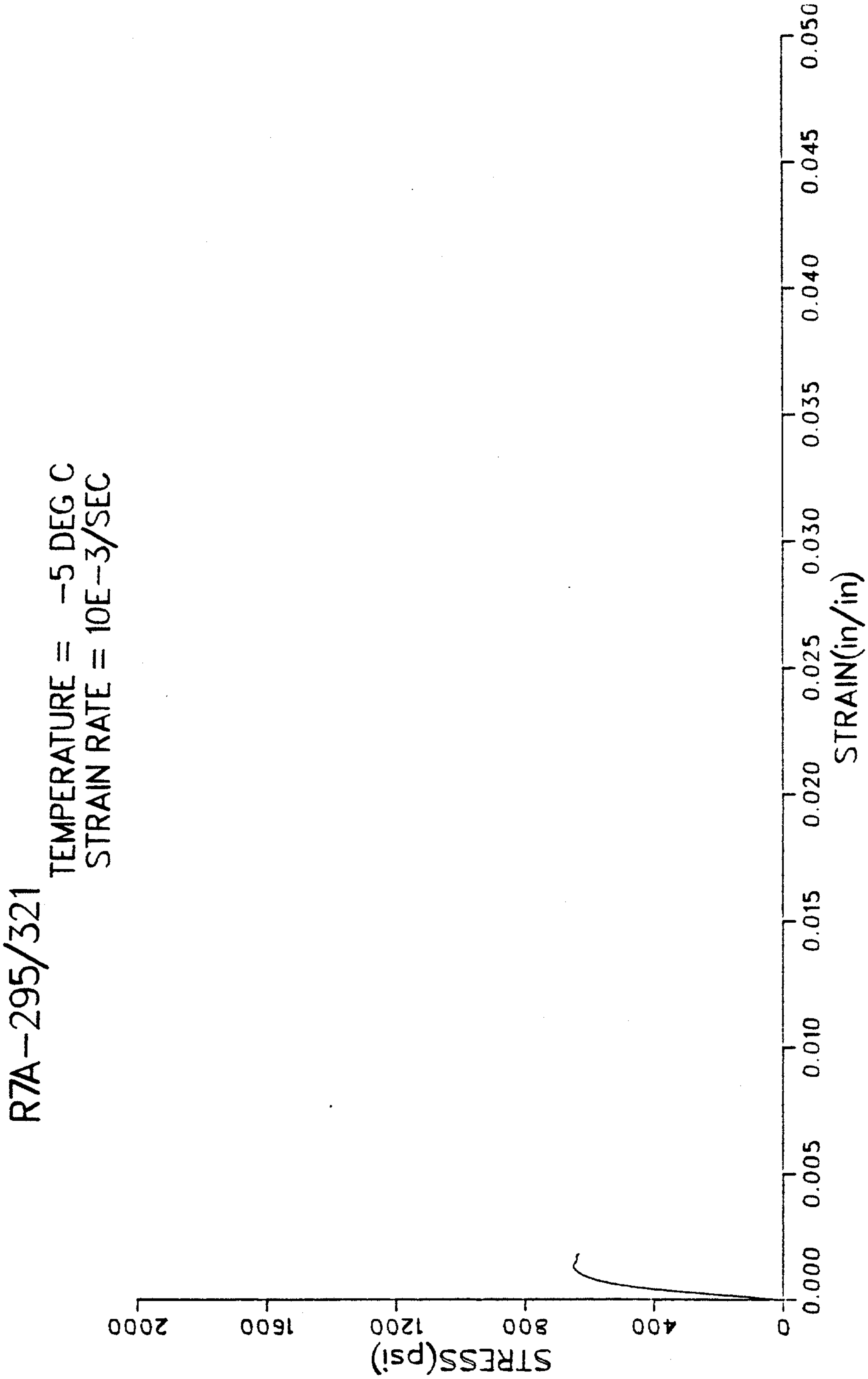

R4B-420/446
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
400
800
1200
1600
2000

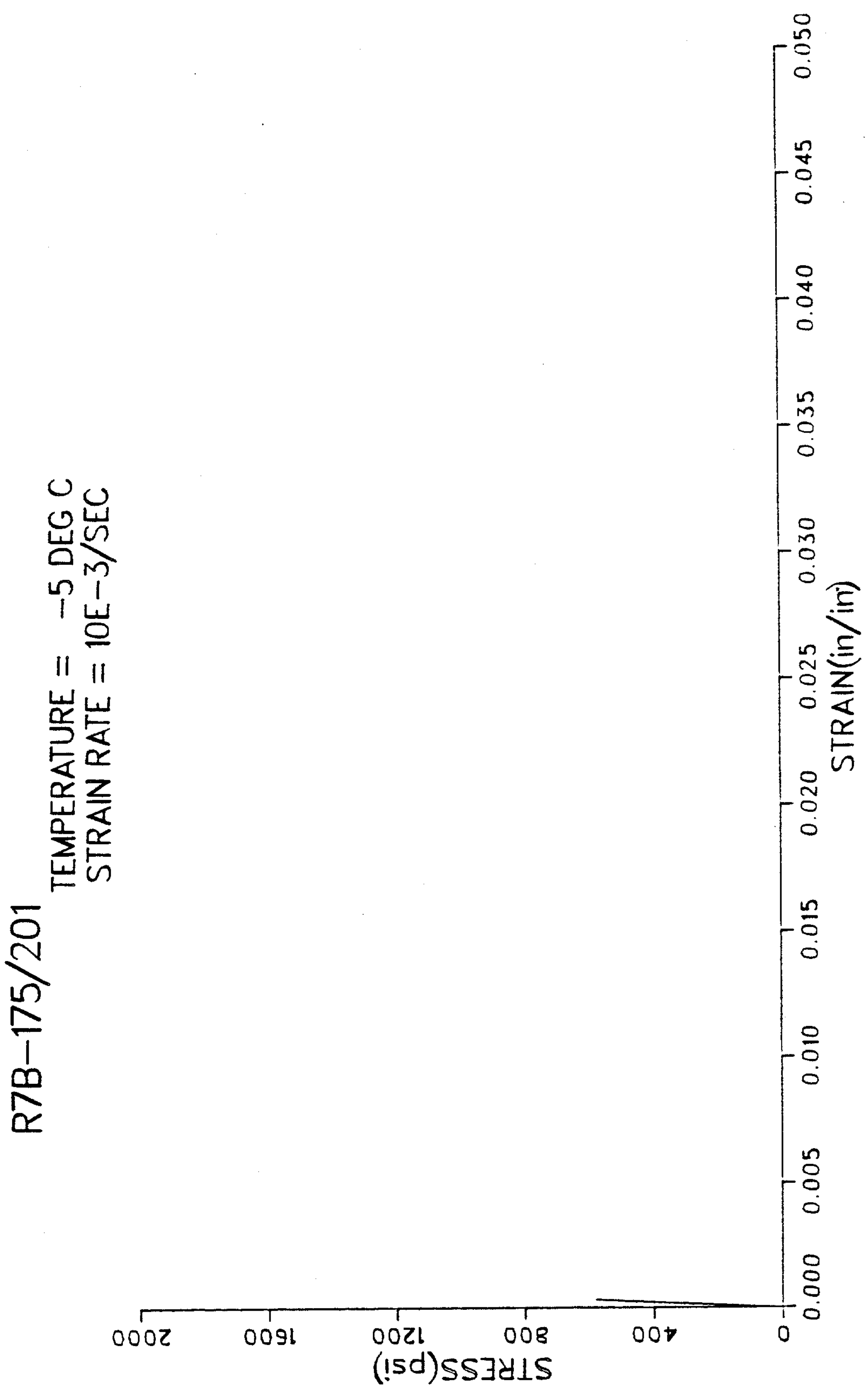

R5A-473/499
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

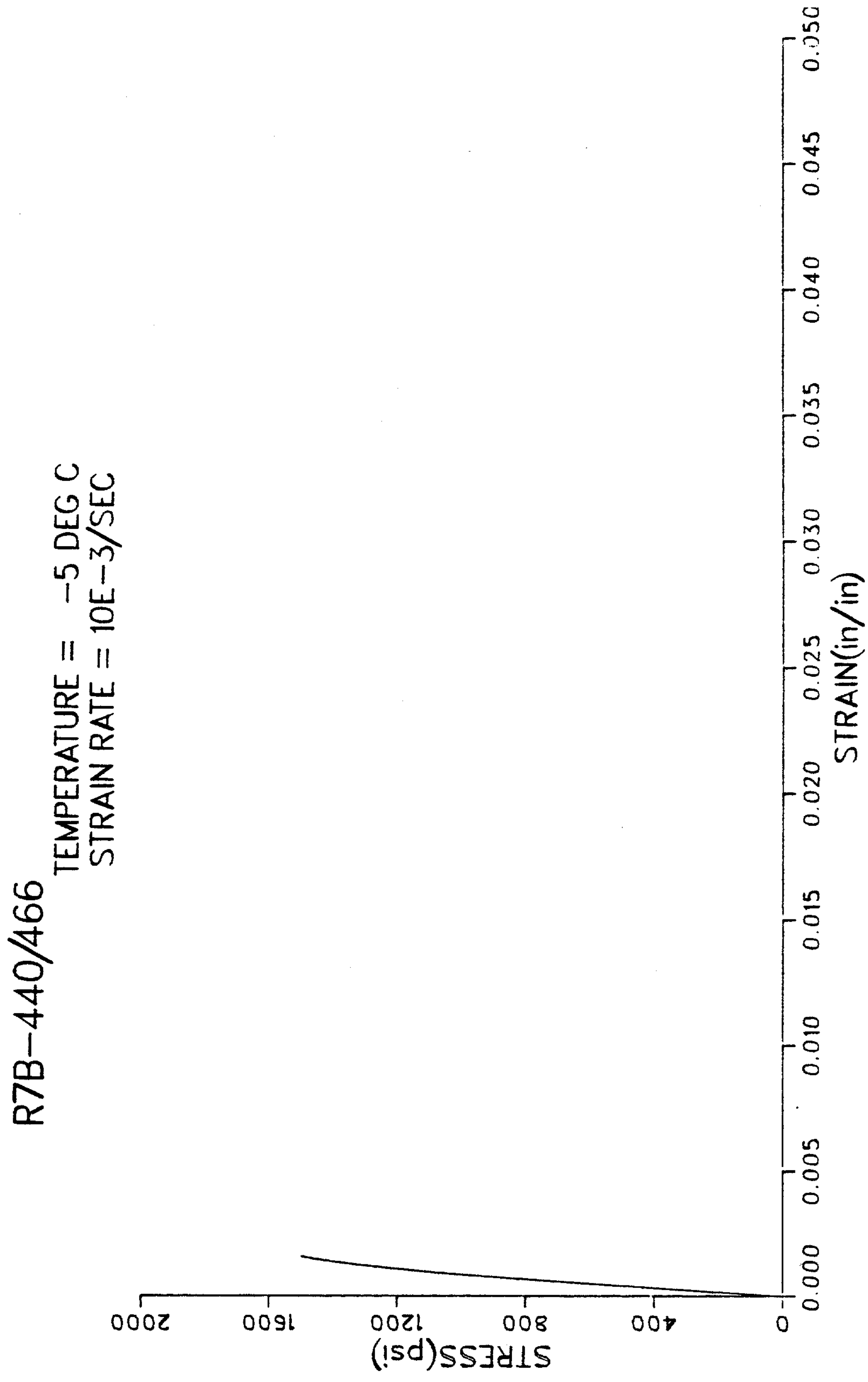

R5B-287/313
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

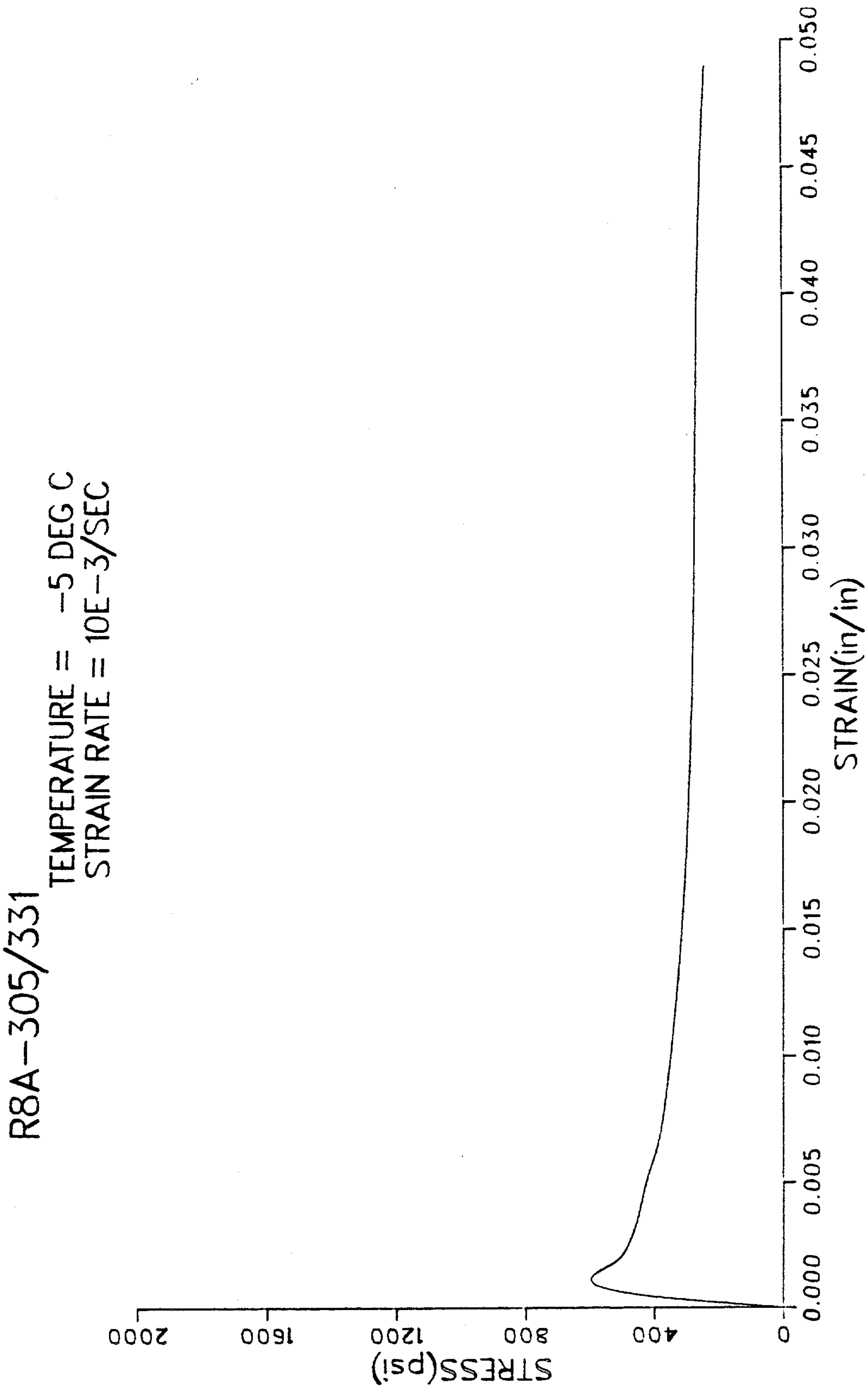

R5B-370/396
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

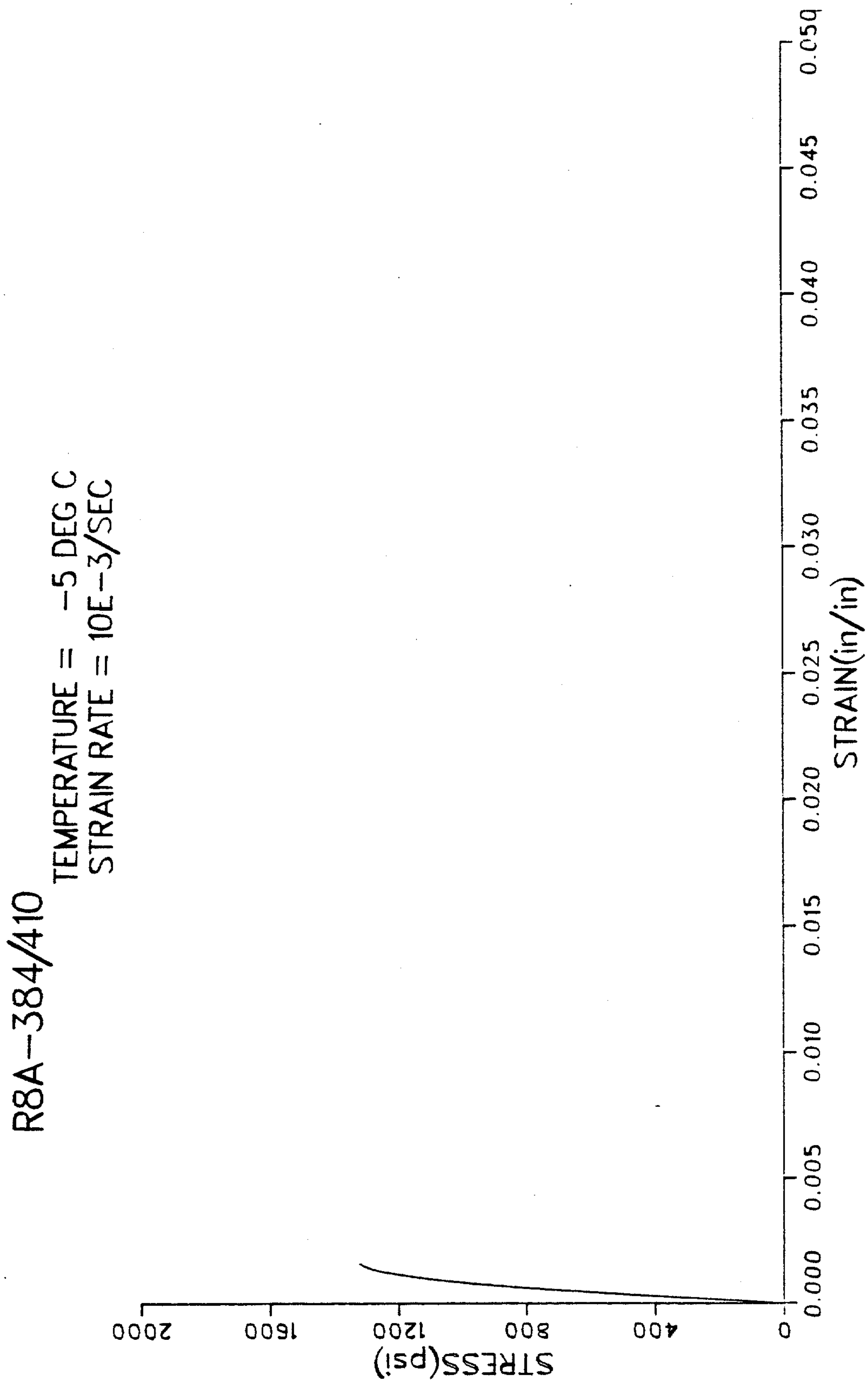

R7A-232/258
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

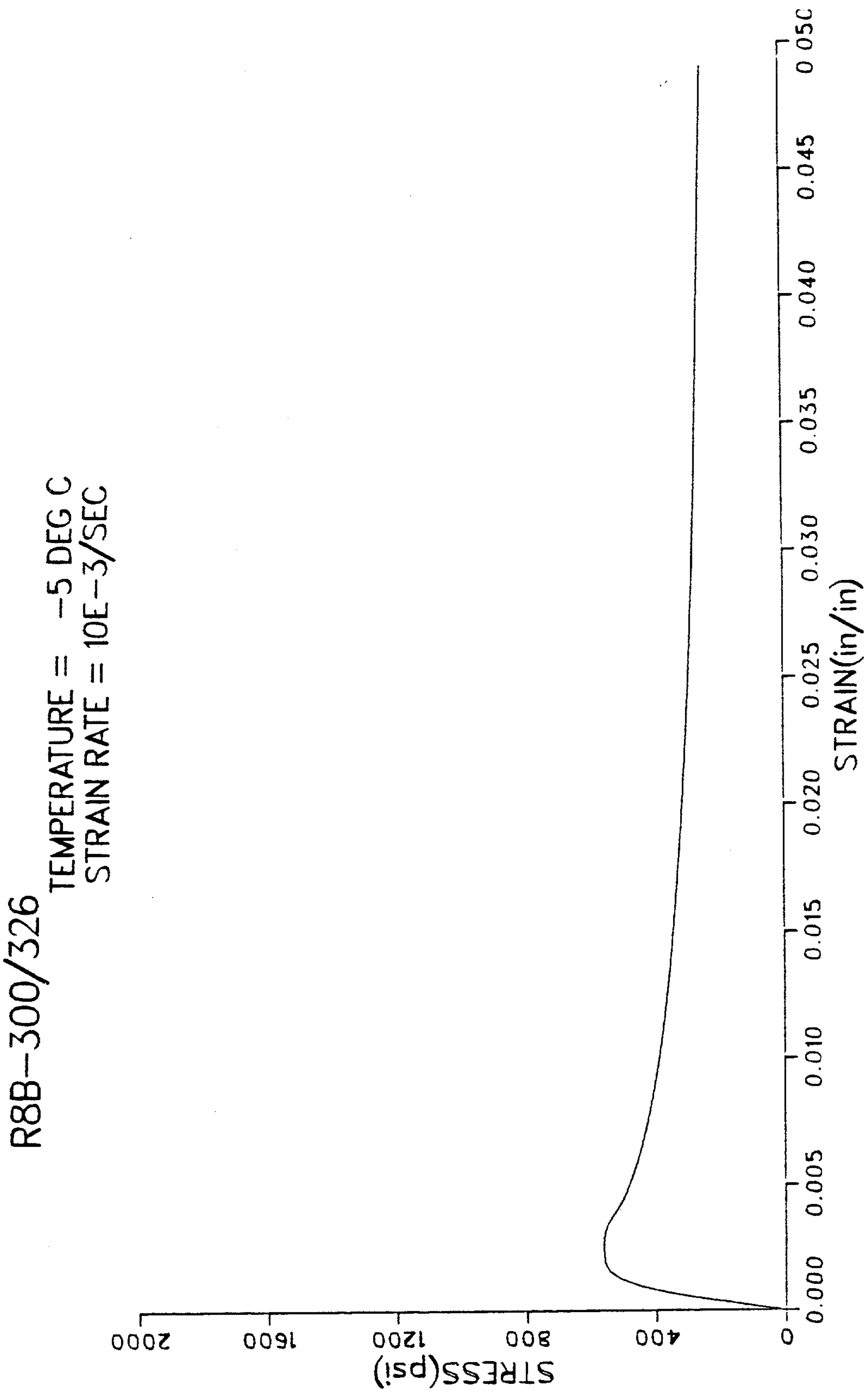

R7A-295/321
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

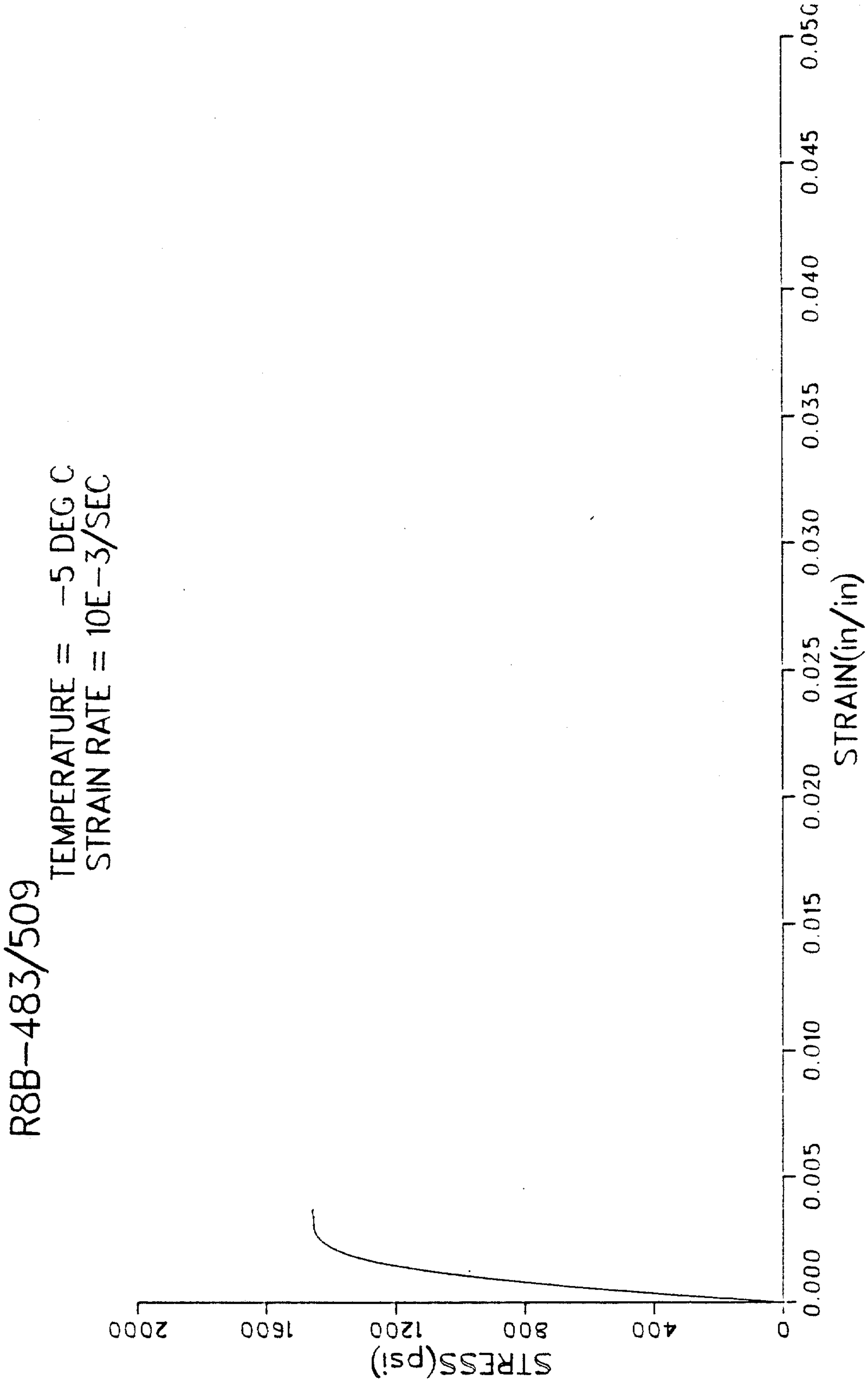

R7B-175/201
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000

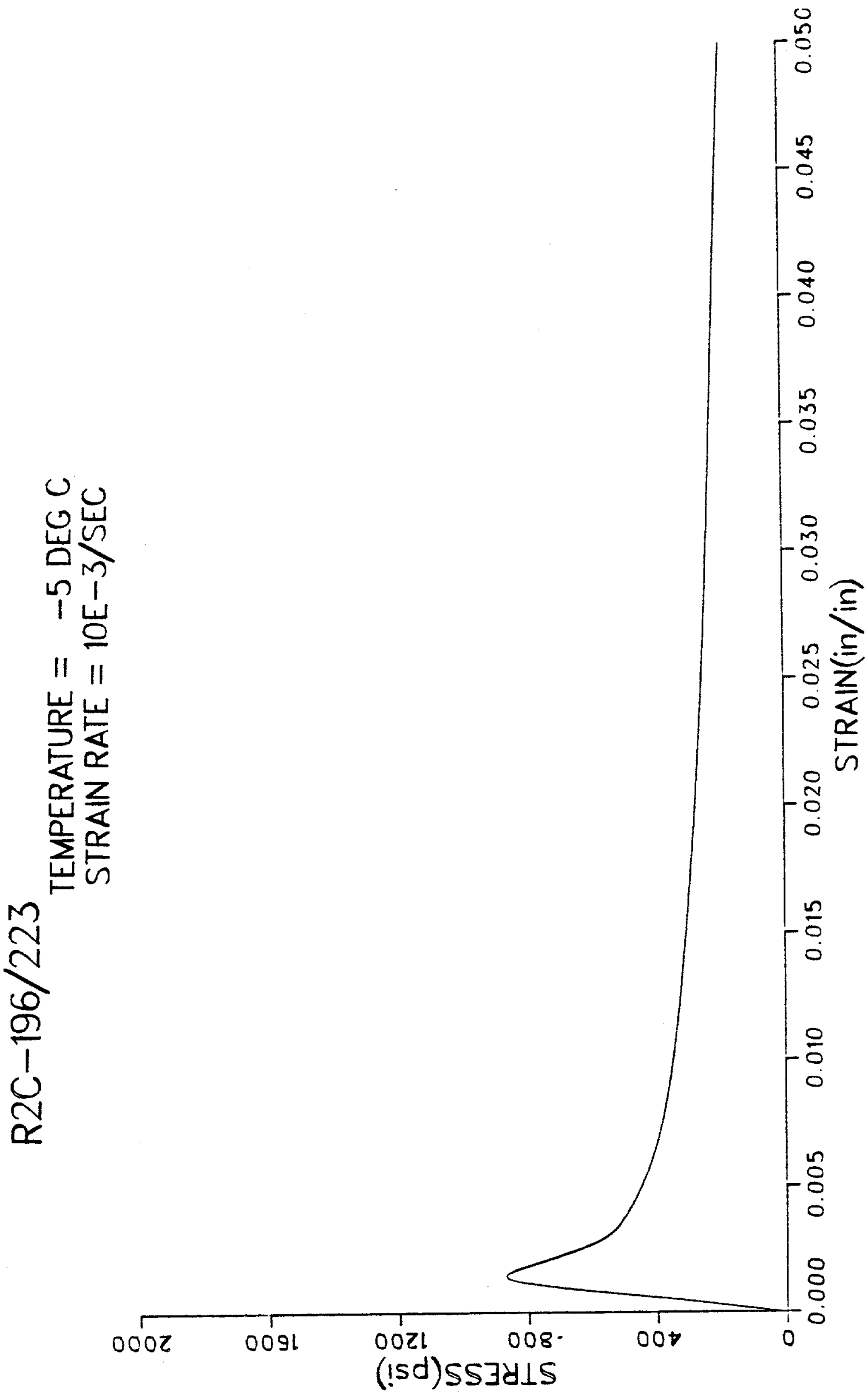

R7B-440/466
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
400
800
1200
1600
2000

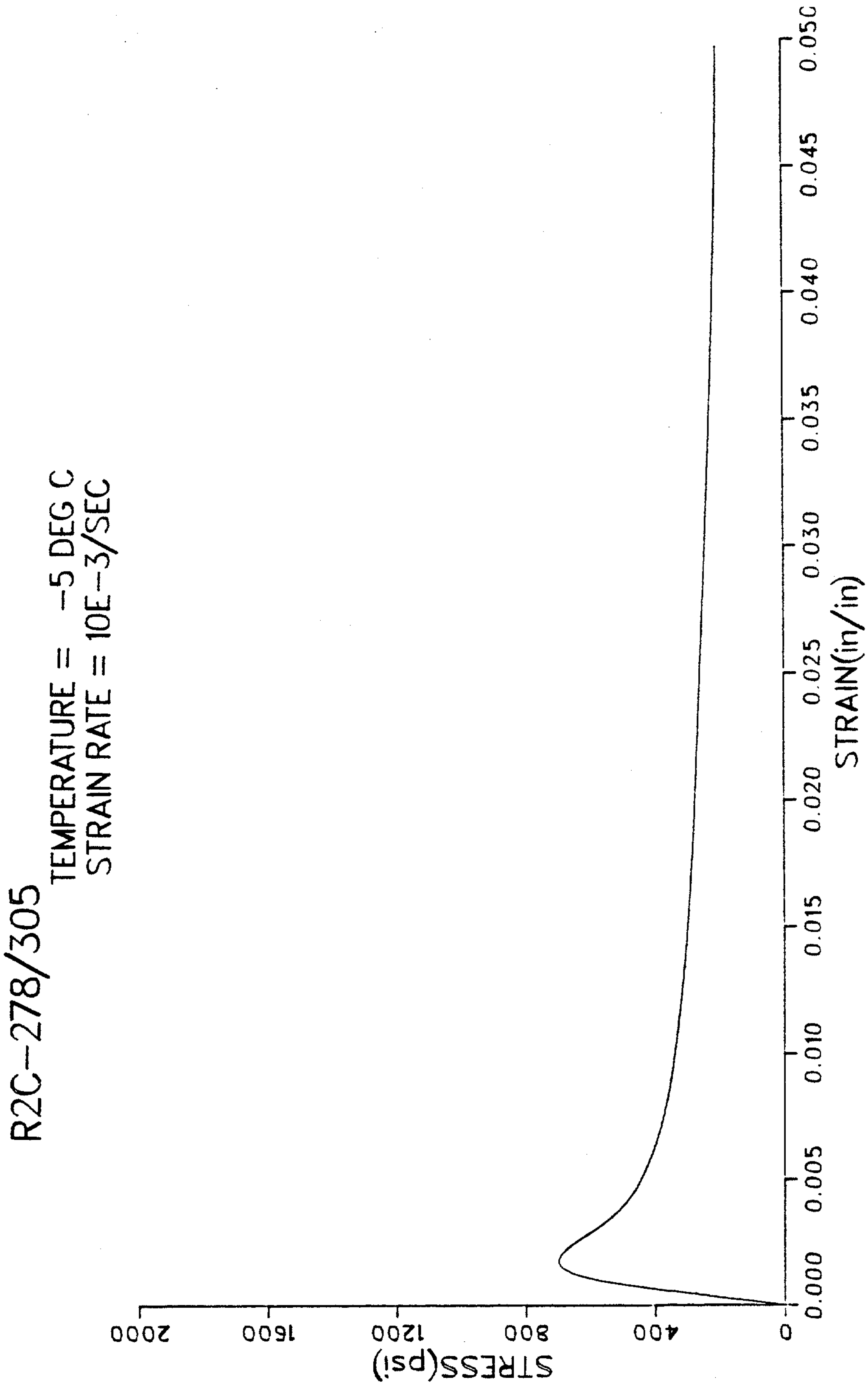

R8A–305/331
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–3/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
400
800
1200
1600
2000

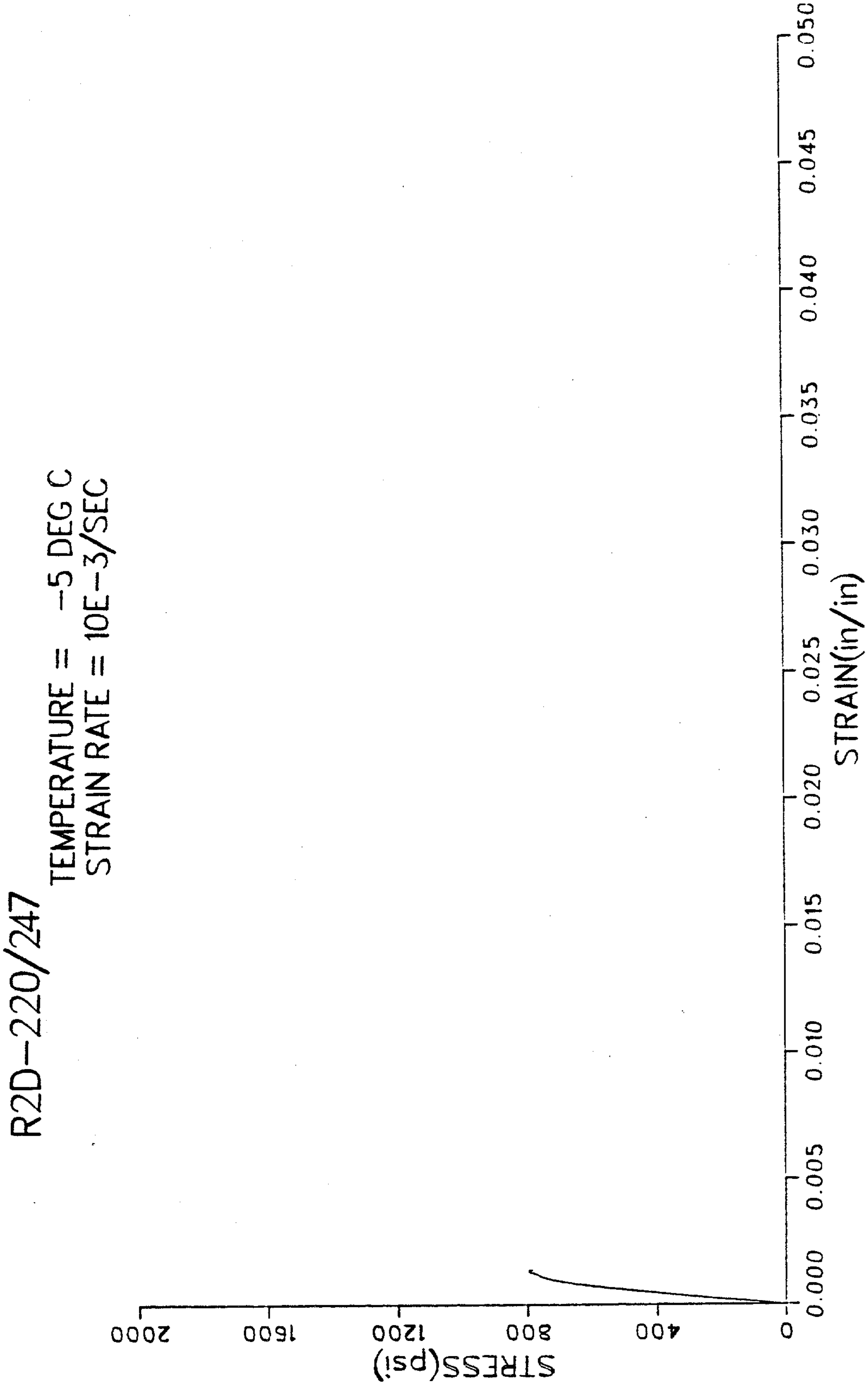

R8A-384/410
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
400
800
1200
1600
2000

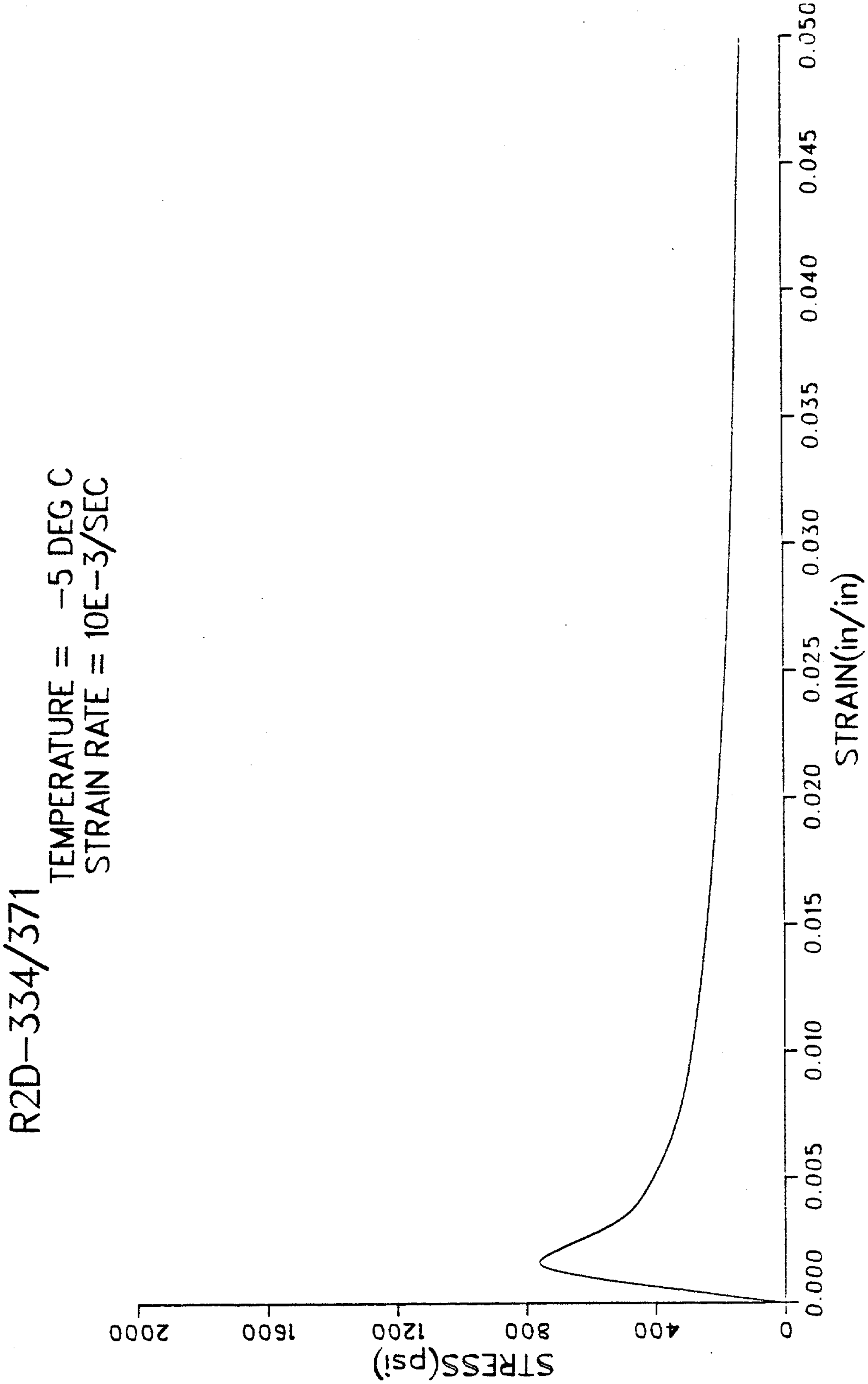

R8B-300/326
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
400
800
1200
1600
2000

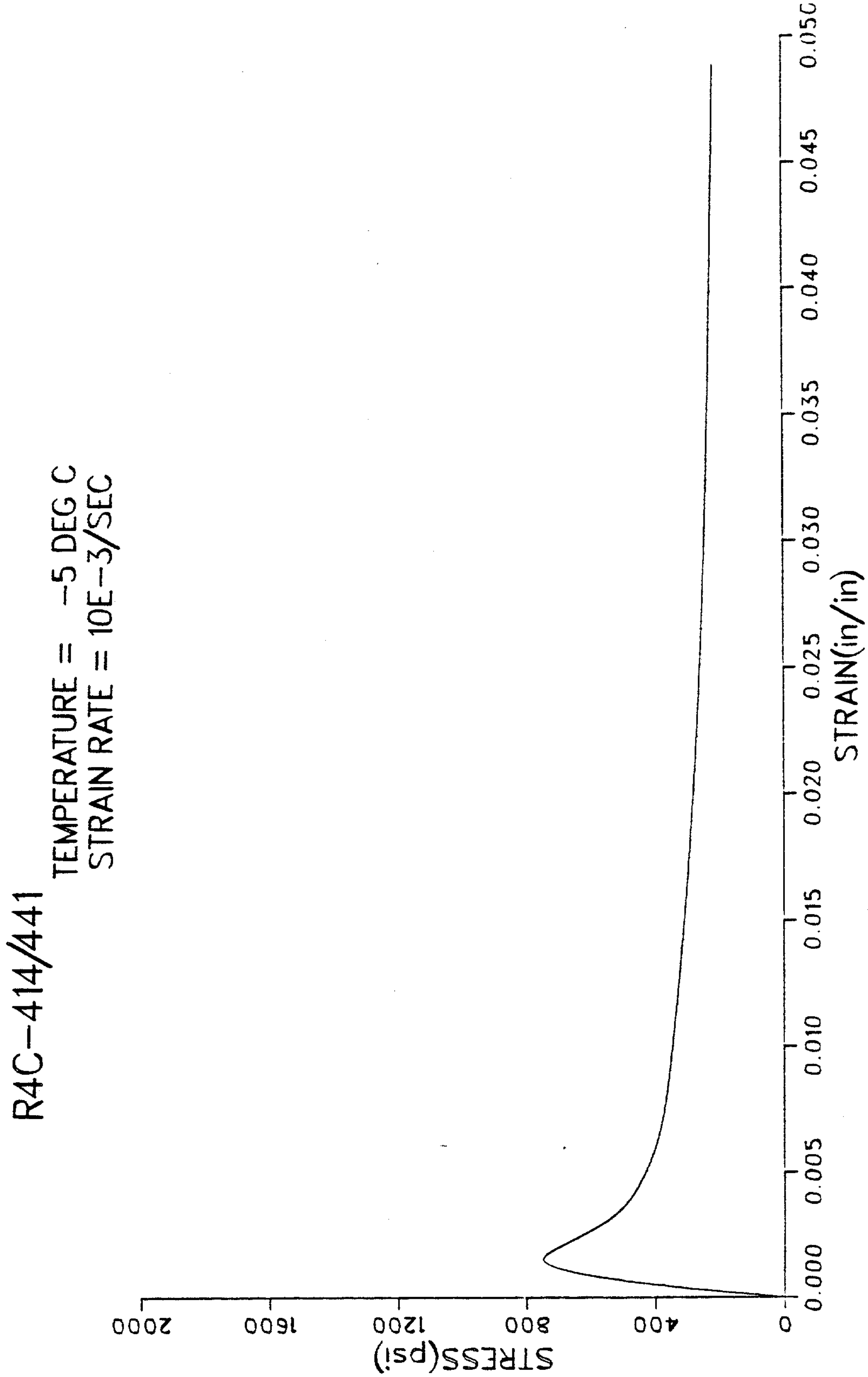

R8B-483/509
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

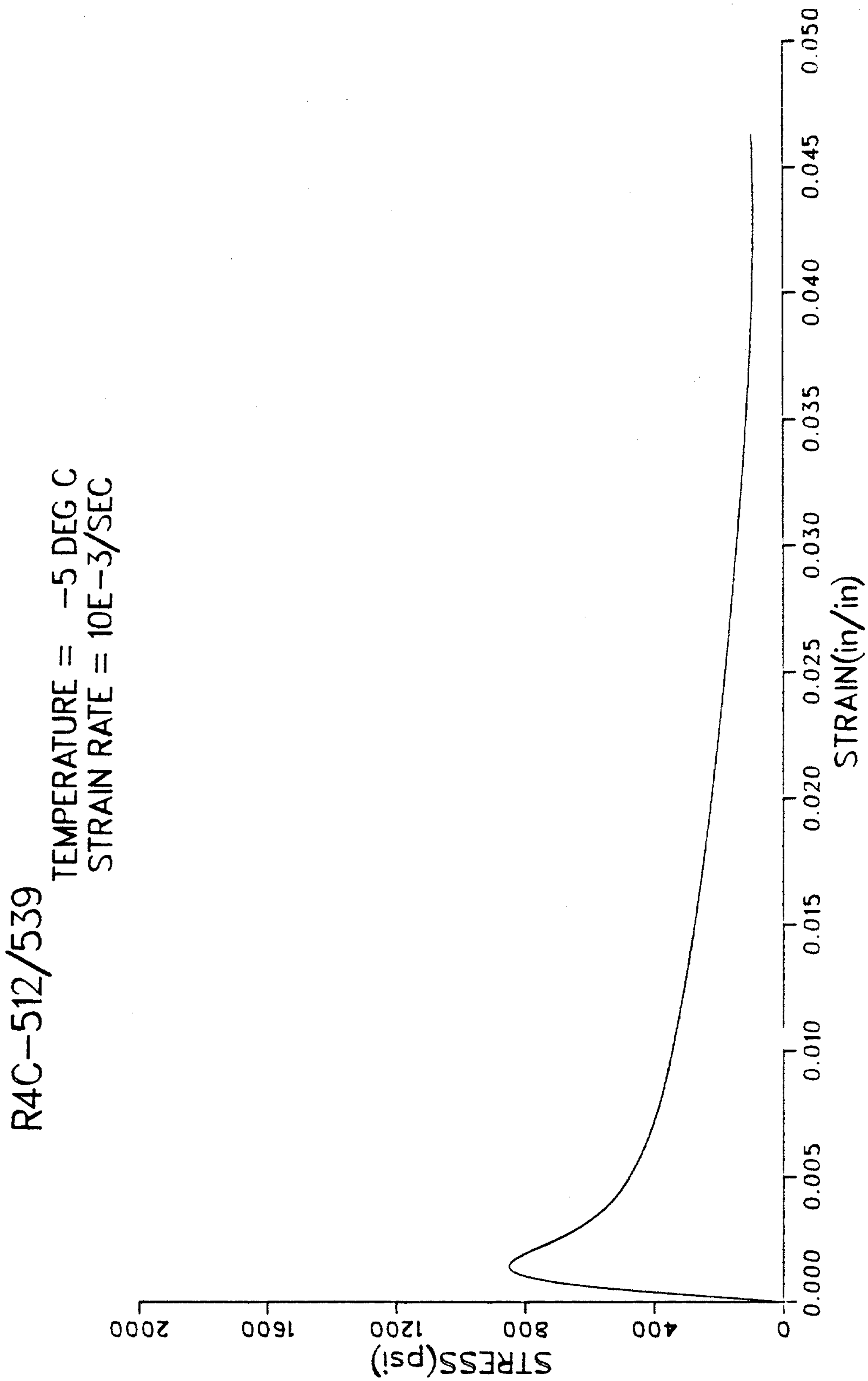

R2C-196/223
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000

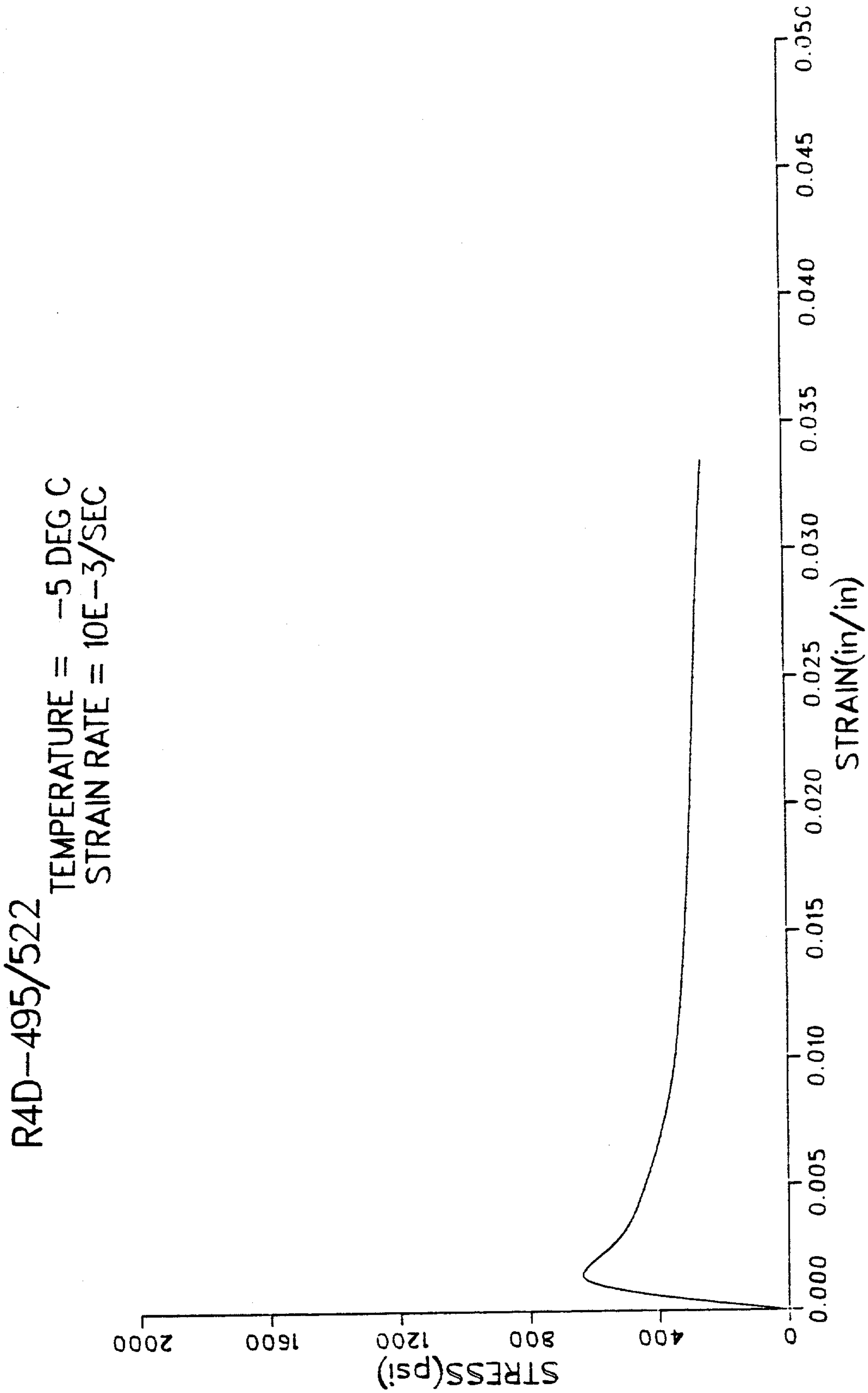

R2C–278/305
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

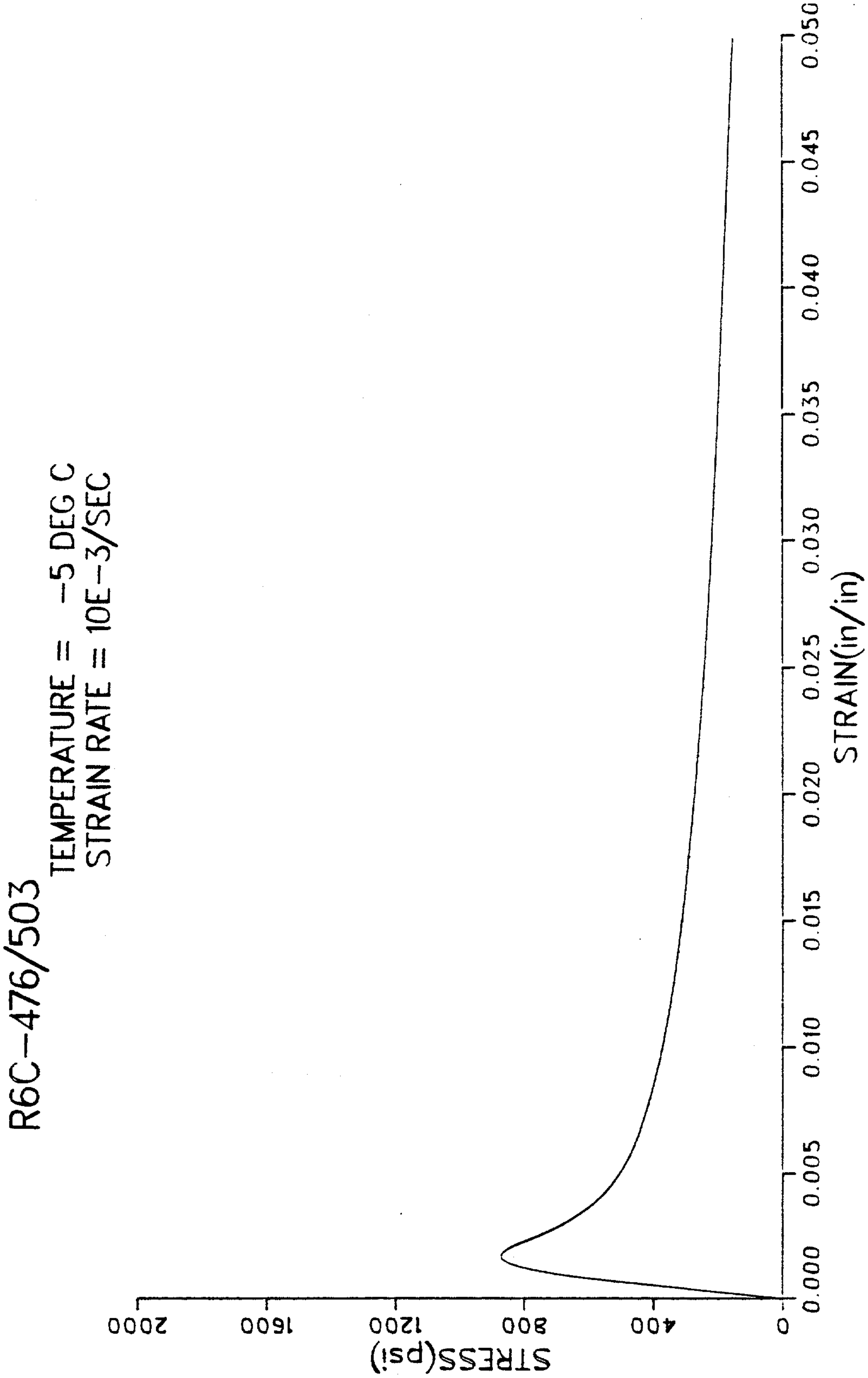

R2D-220/247
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000

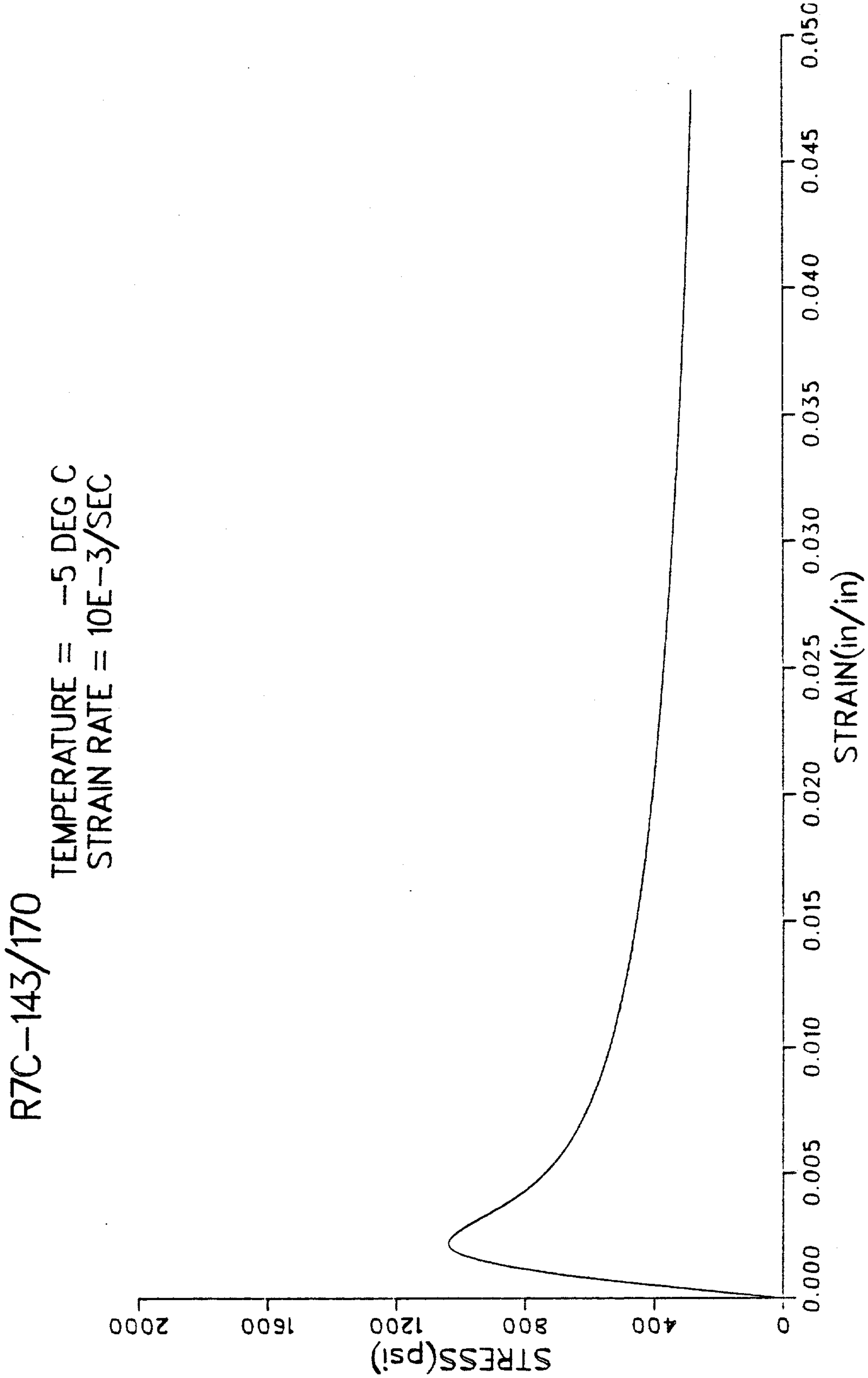

R2D-334/371
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

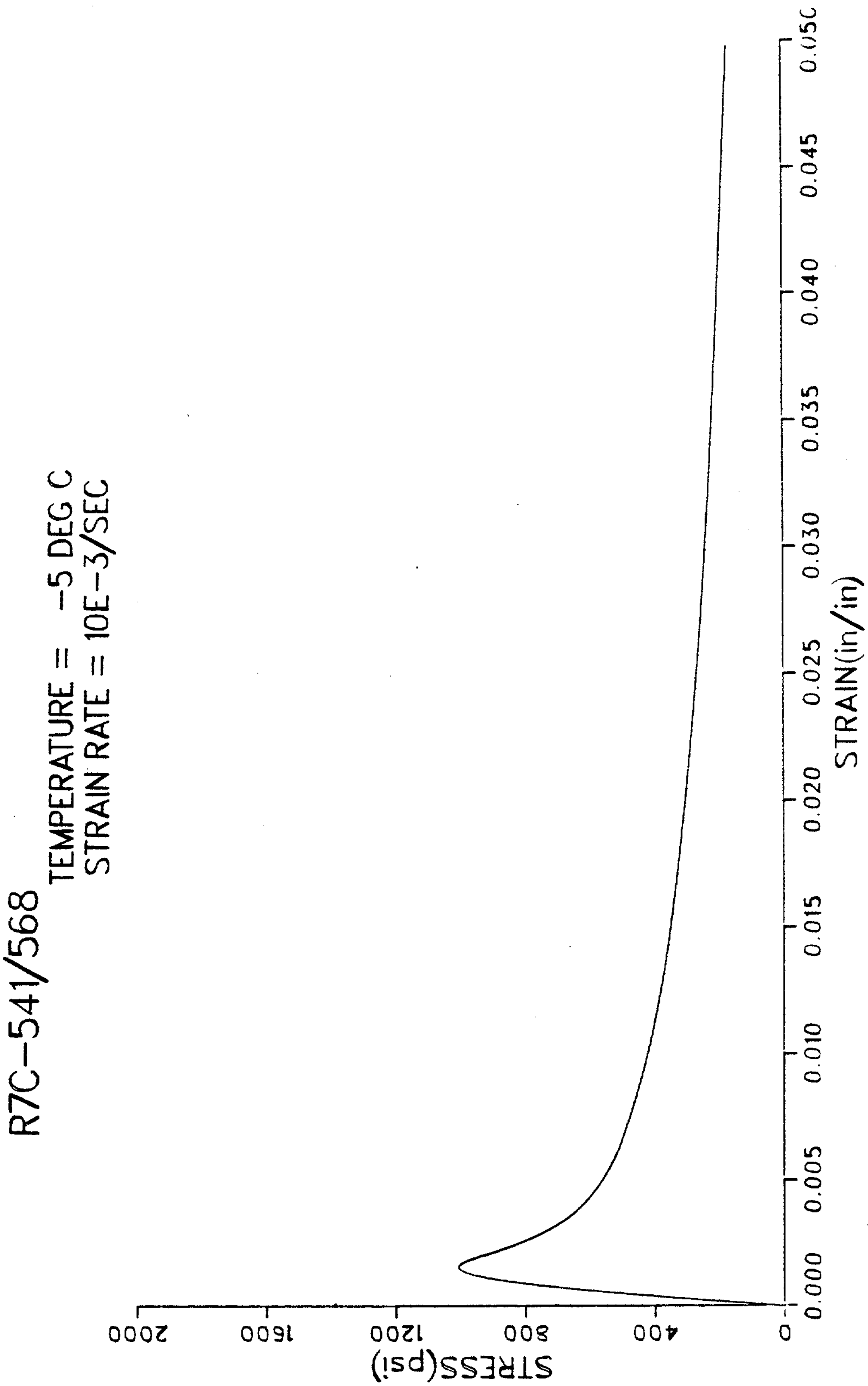

R4C-414/441
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
400
800
1200
1600
2000

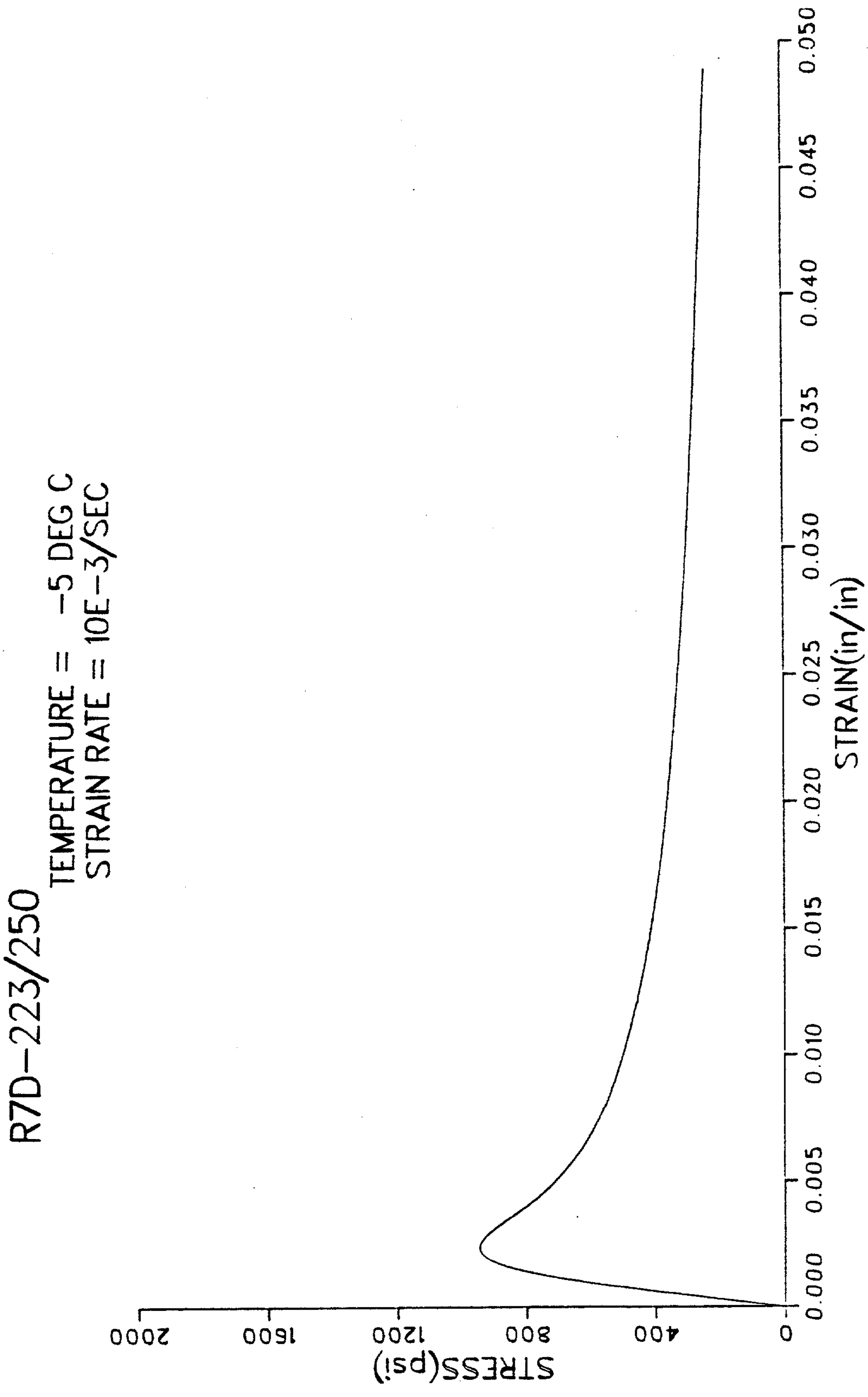

R4C–512/539
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

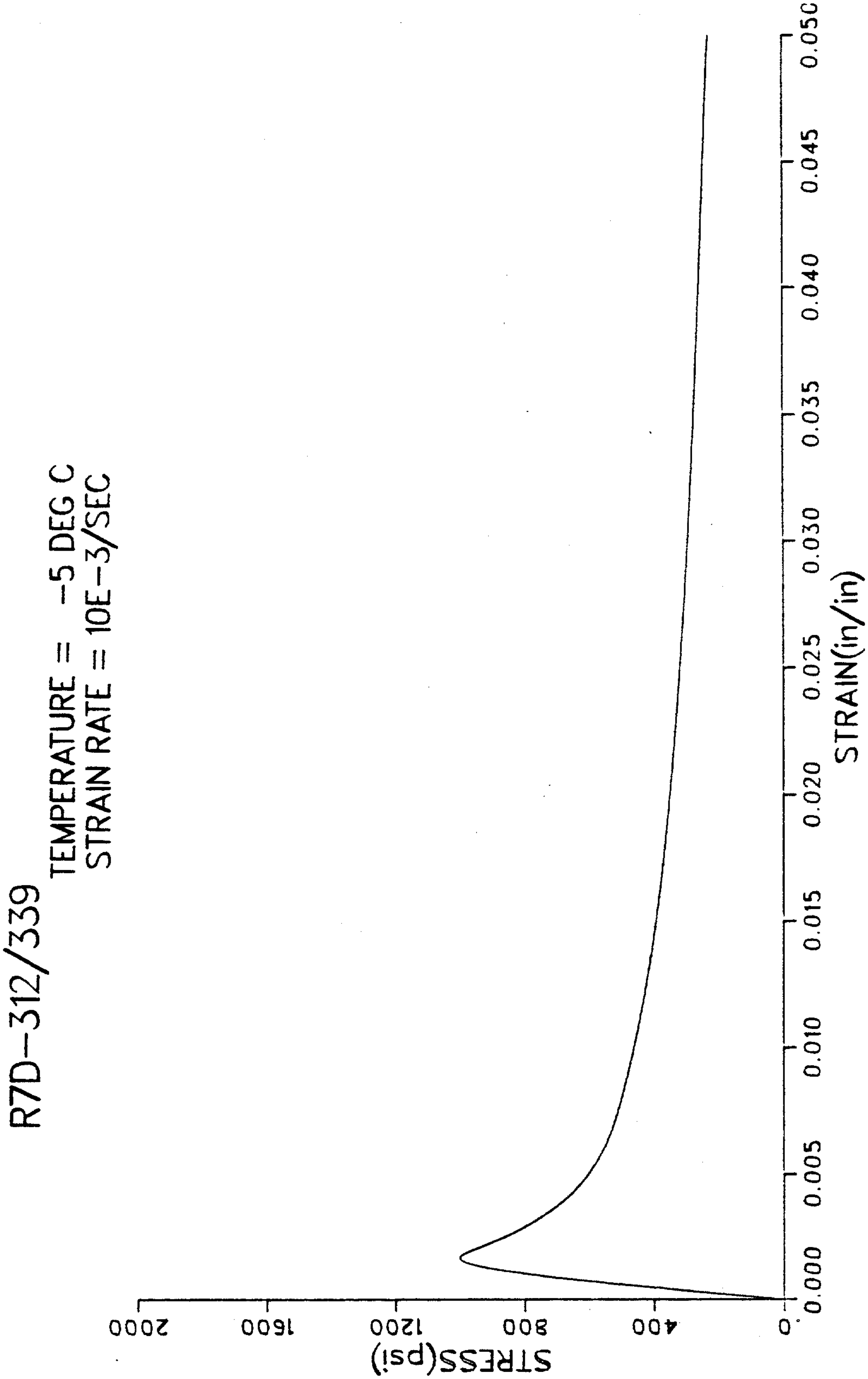

R4D-495/522
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

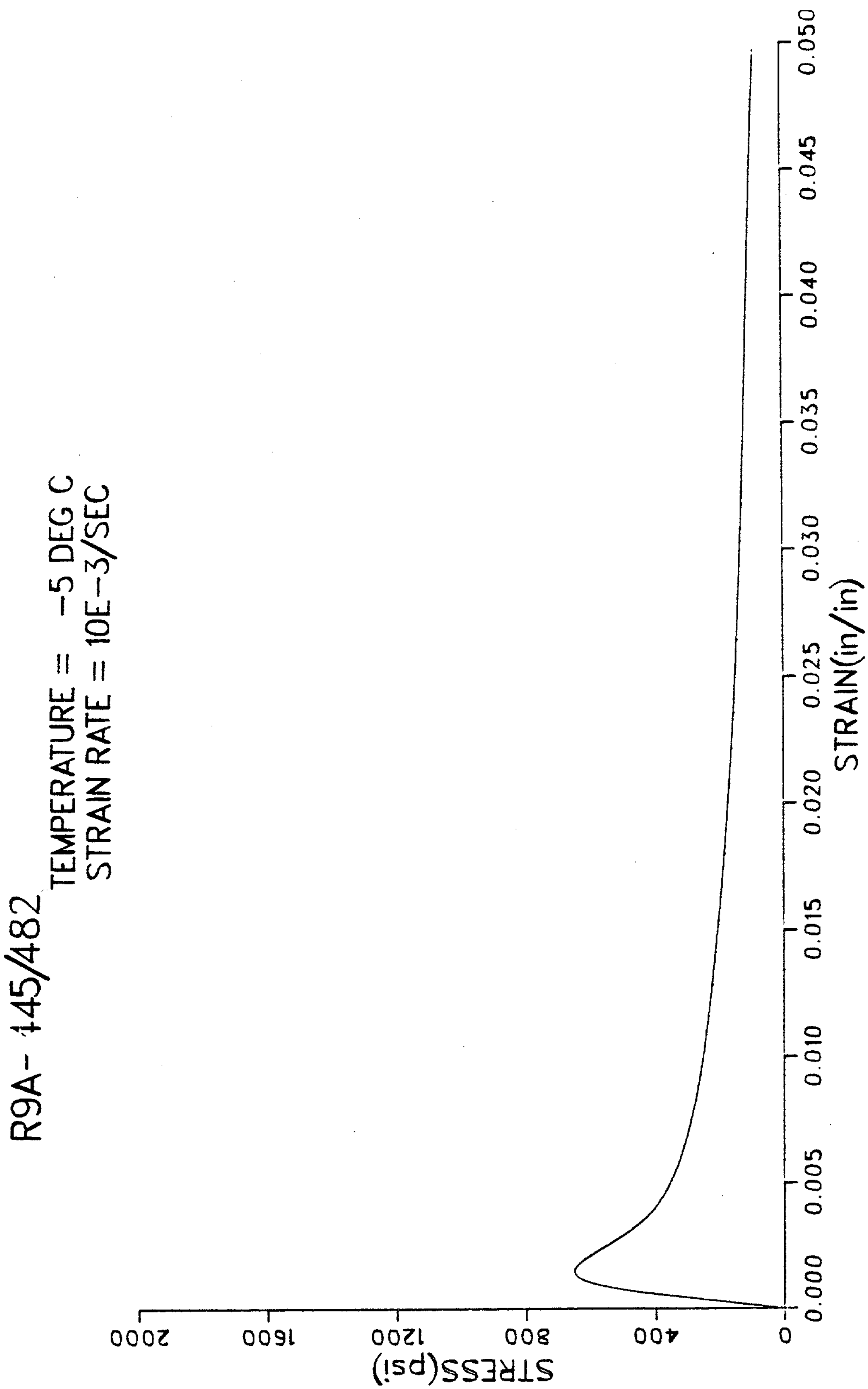

R6C-476/503
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

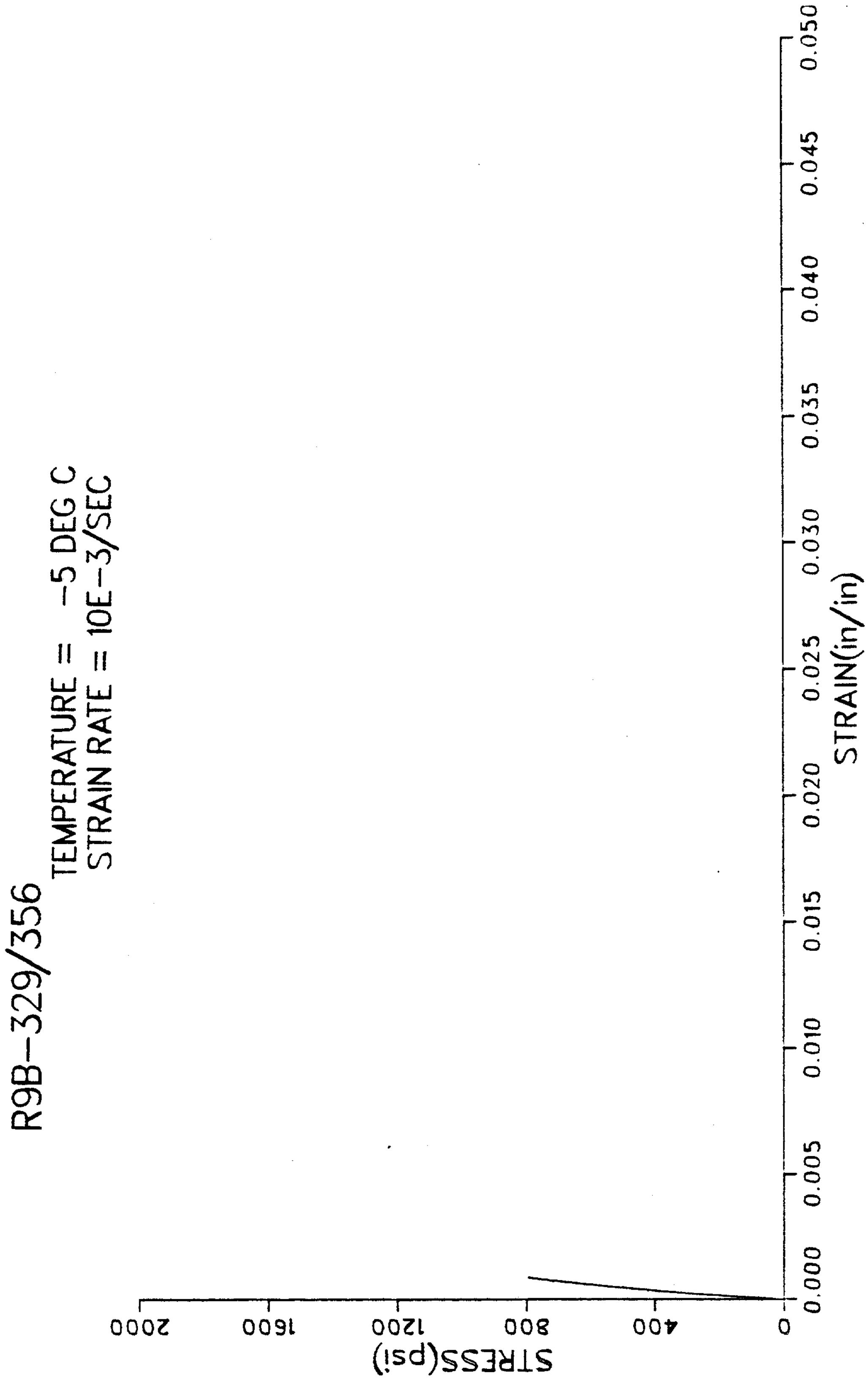

R7C-143/170
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

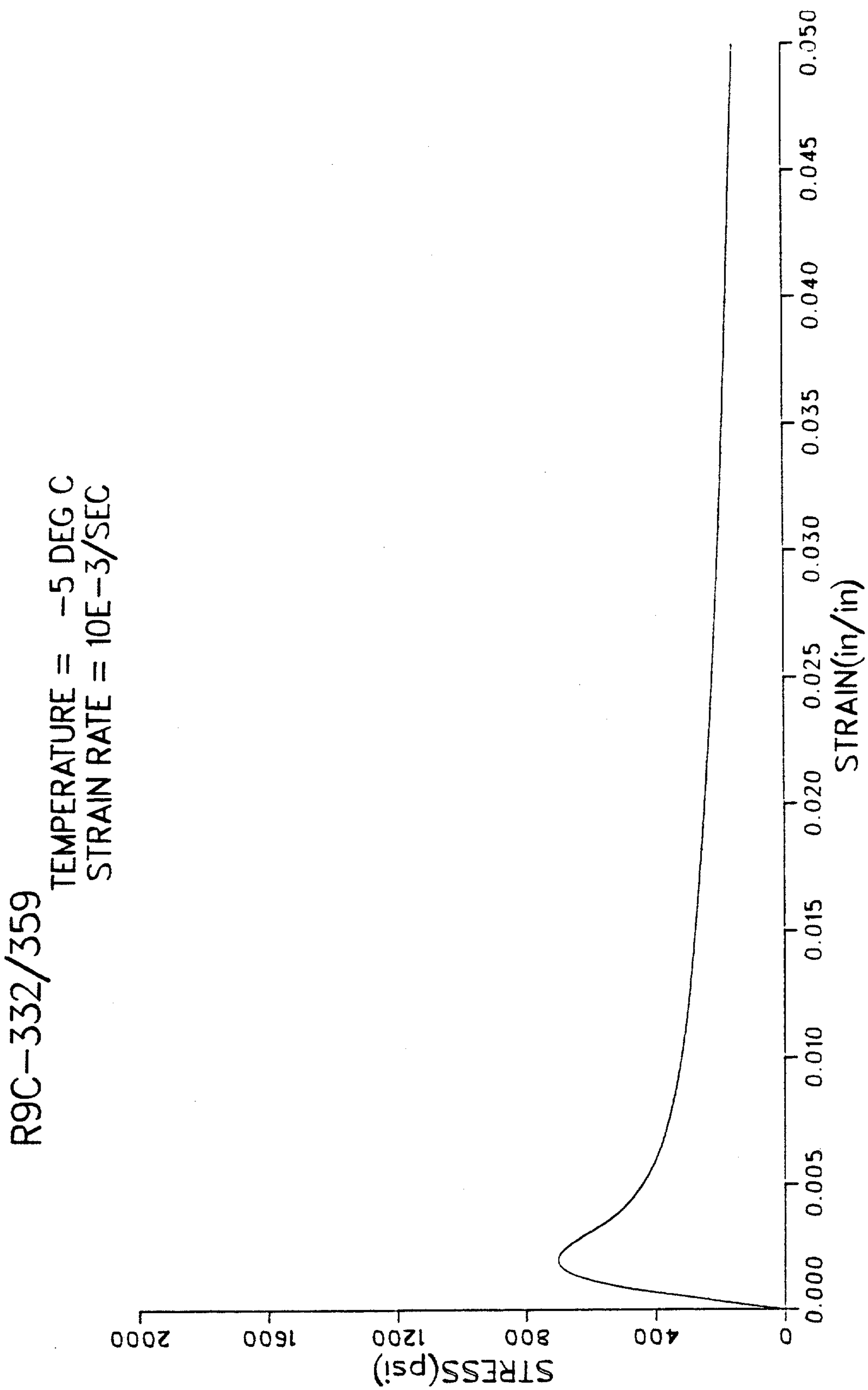

R7C-541/568
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

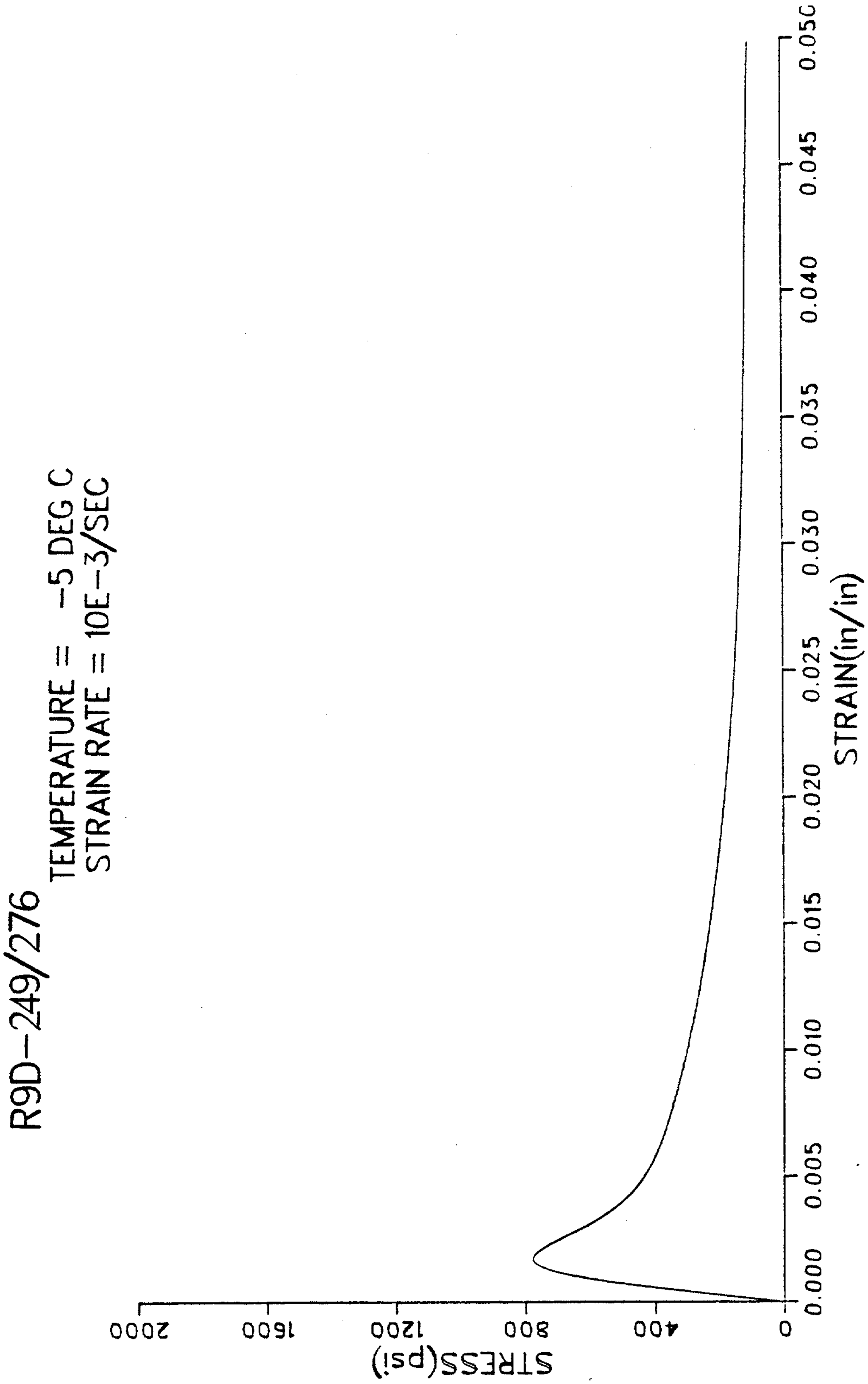

R7D-223/250
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

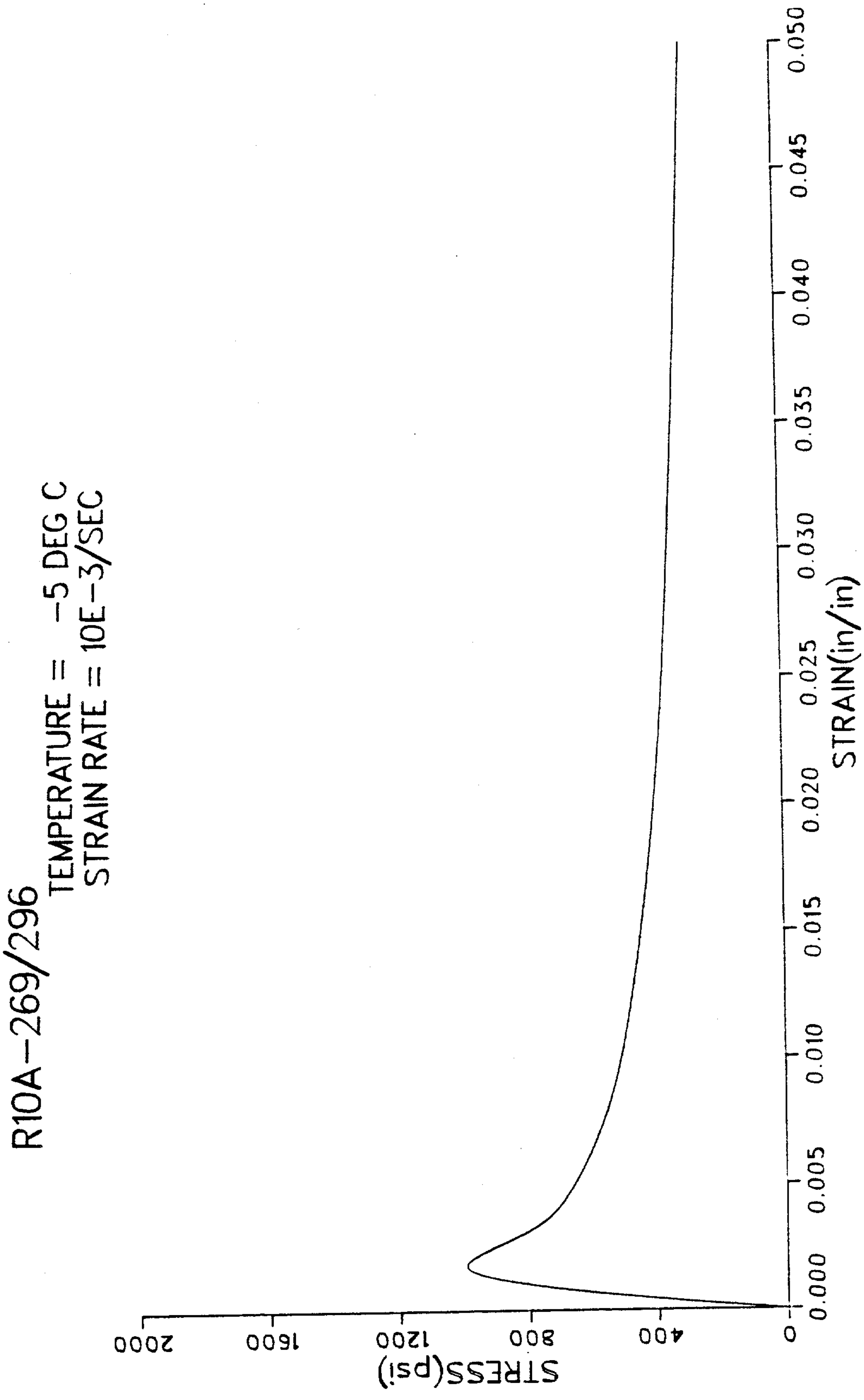

R7D-312/339
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

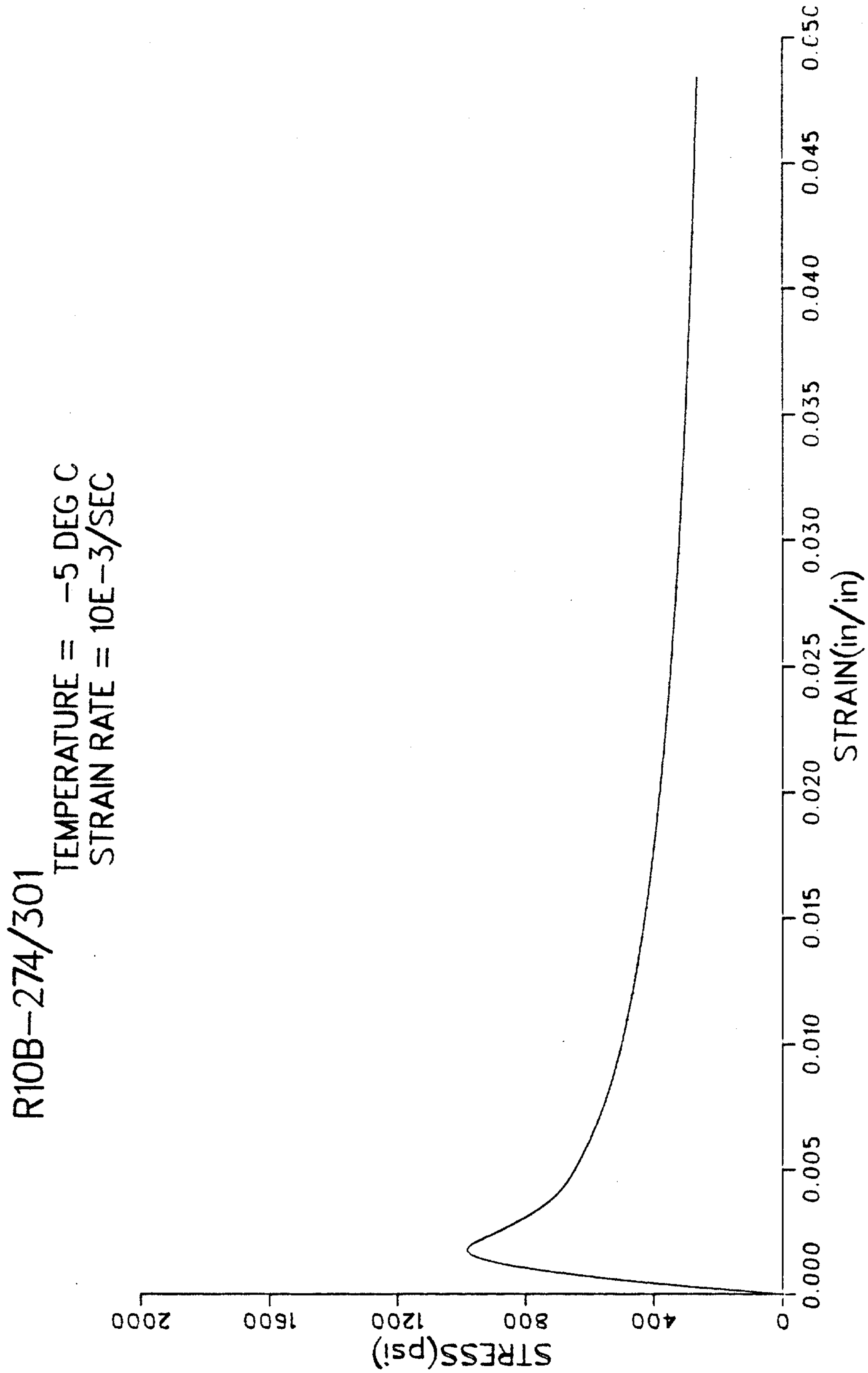

R9A- 145/482
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000

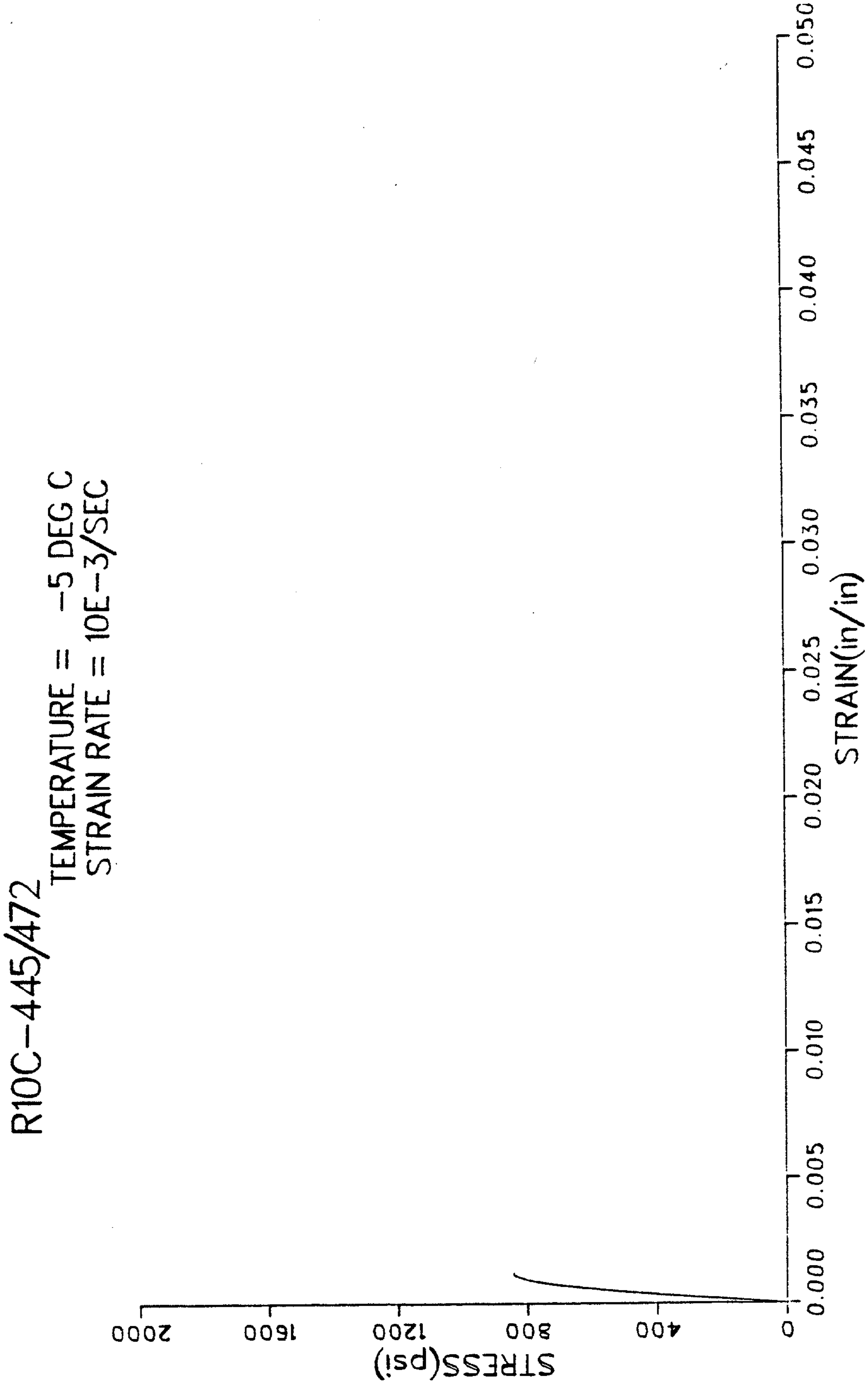

R9B-329/356
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000

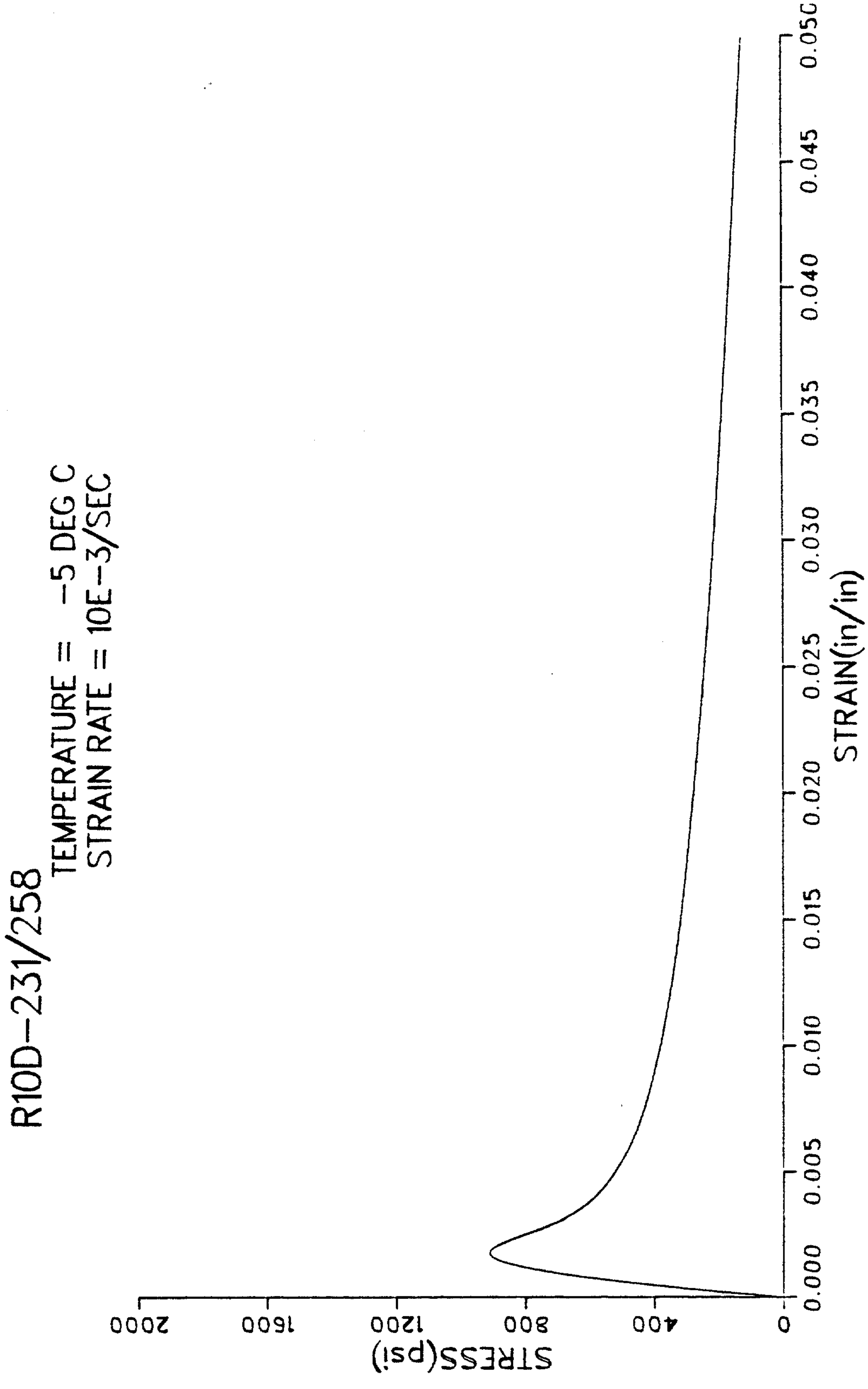

R9C-332/359
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050


R9D-249/276
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

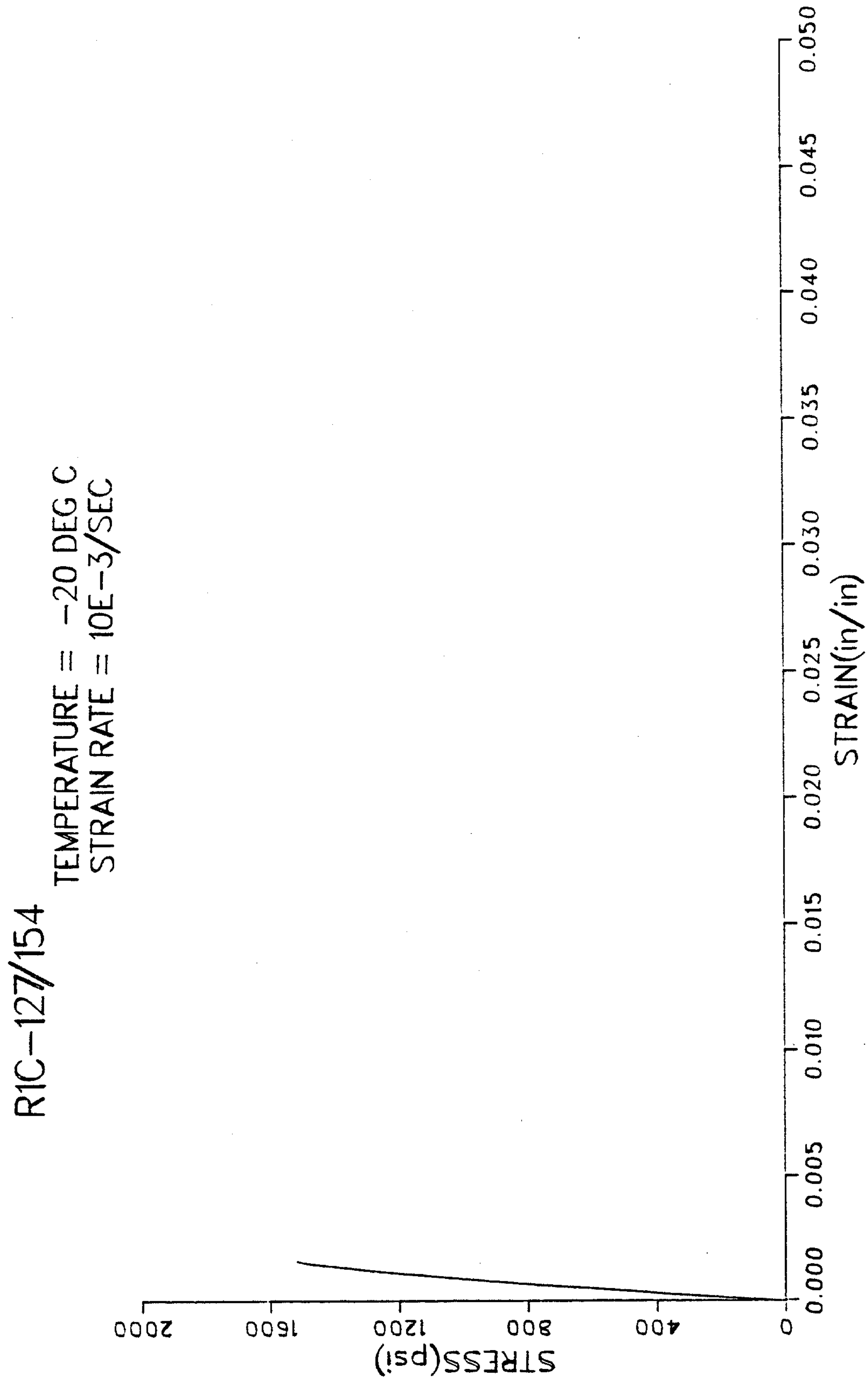

R10A-269/296
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

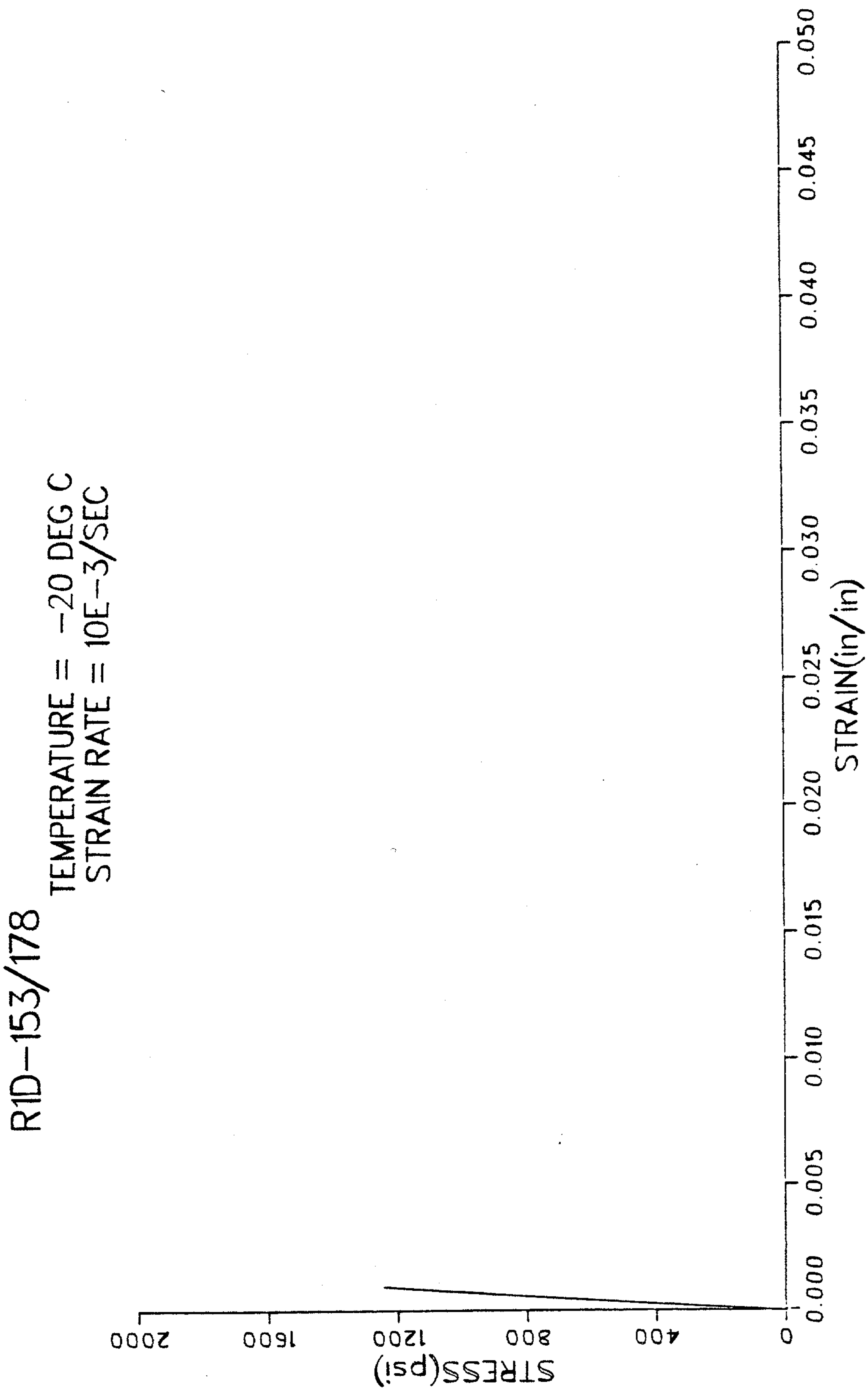

R10B-274/301
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

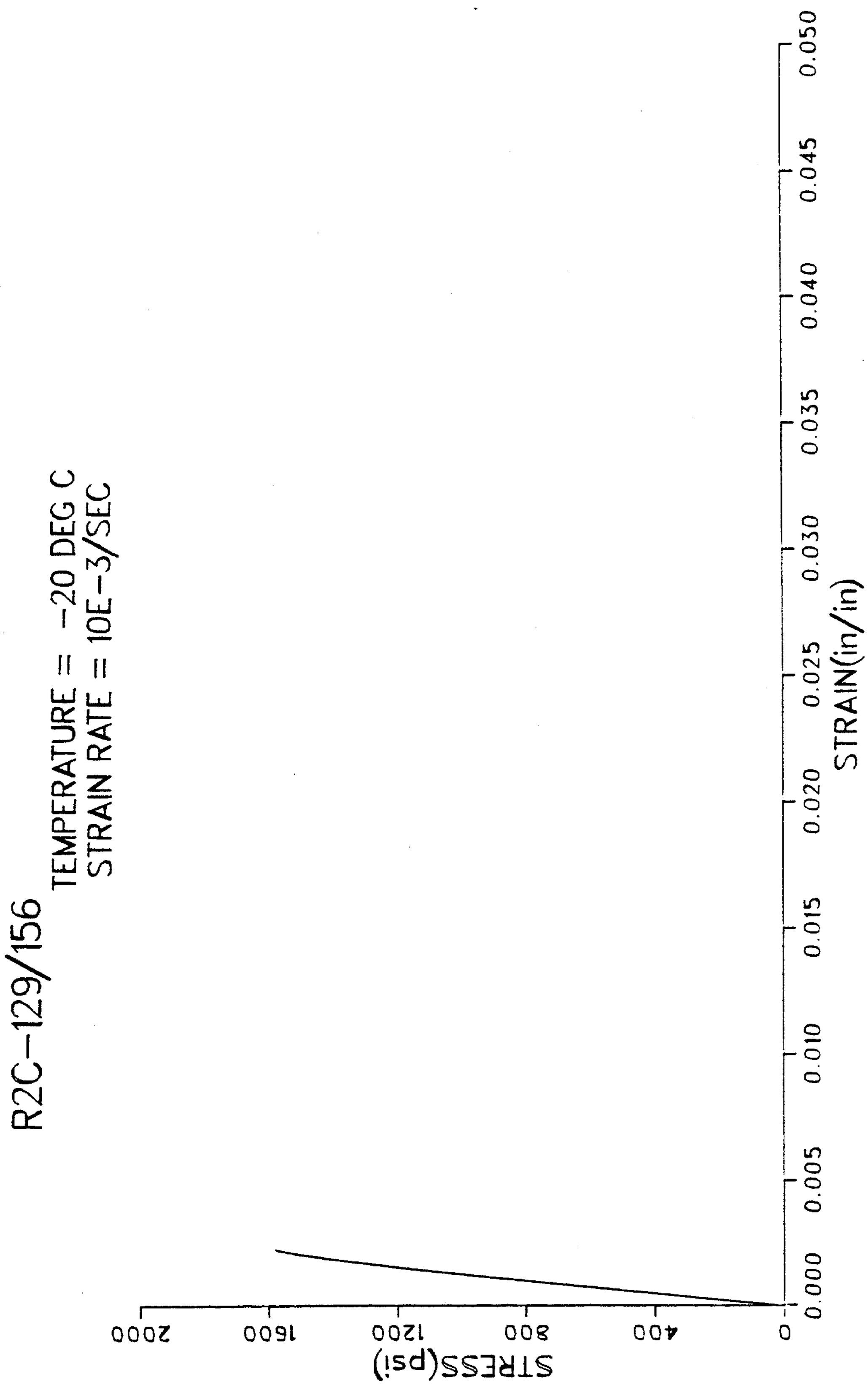

R10C–445/472
TEMPERATURE = –5 DEG C
STRAIN RATE = 10E–3/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000

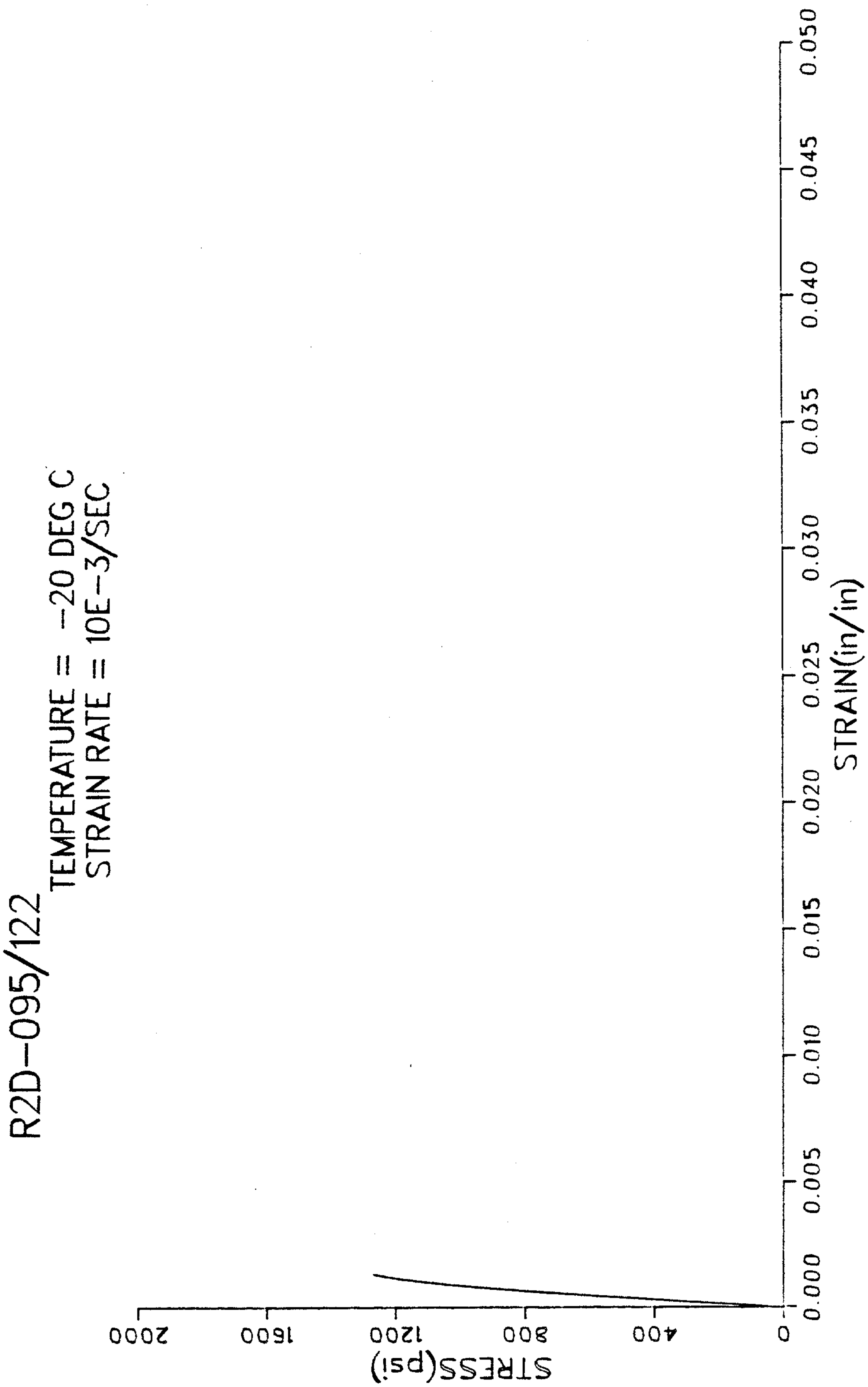

R10D-231/258
TEMPERATURE = -5 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

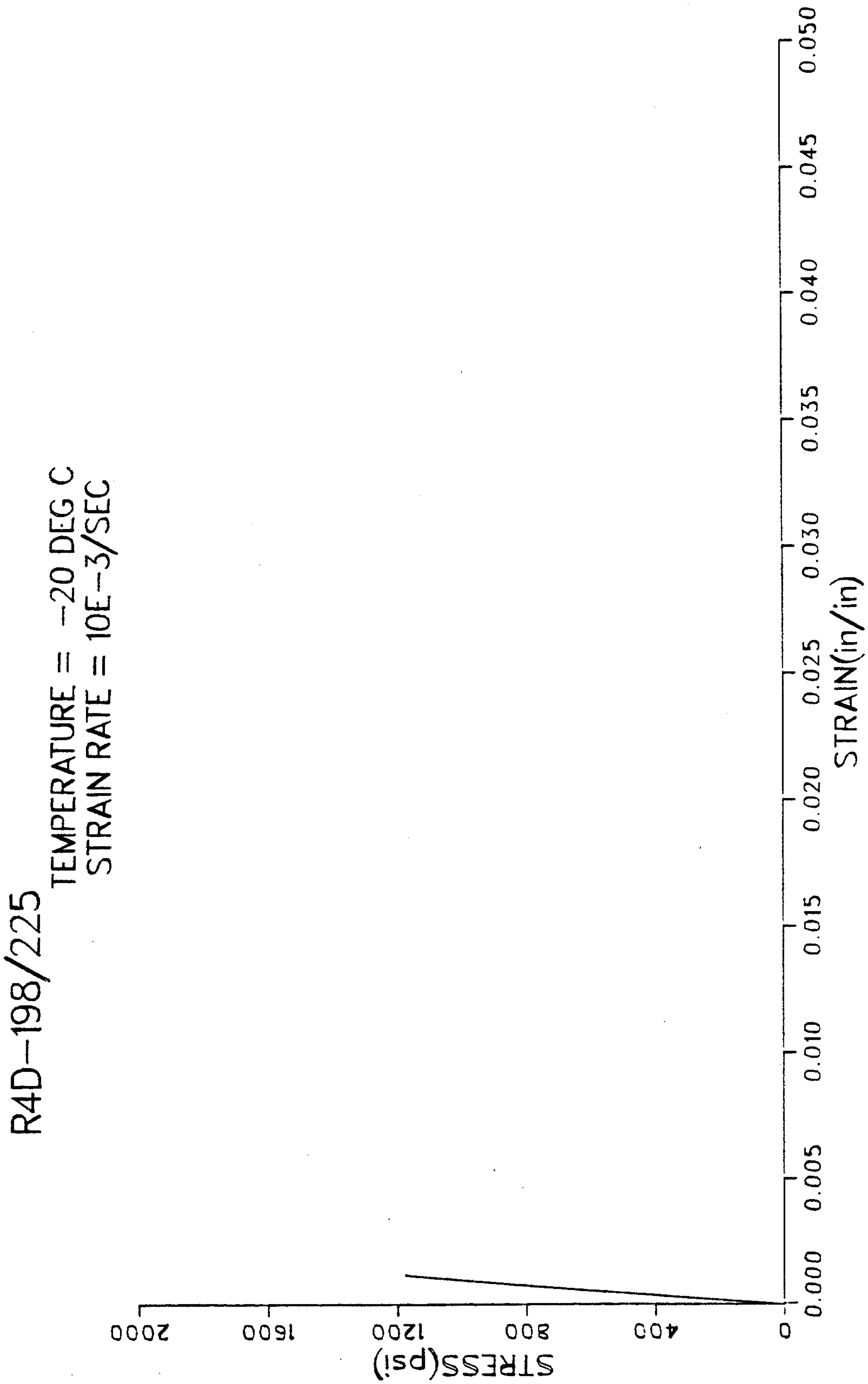
STRAIN RATE = (10E-3)/SEC
TEMPERATURE = -20°C

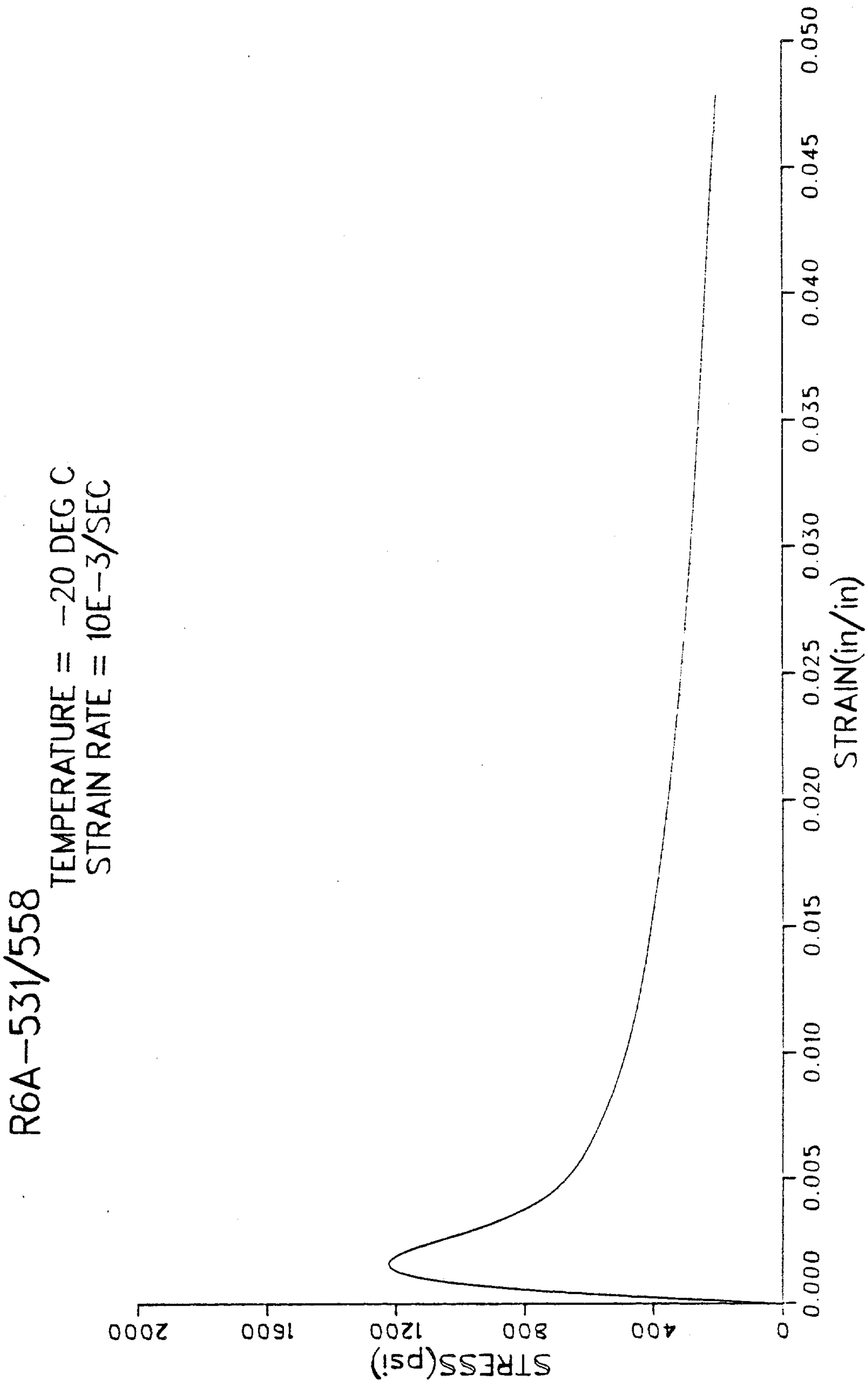

R1C-127/154
TEMPERATURE = −20 DEG C
STRAIN RATE = 10E−3/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000

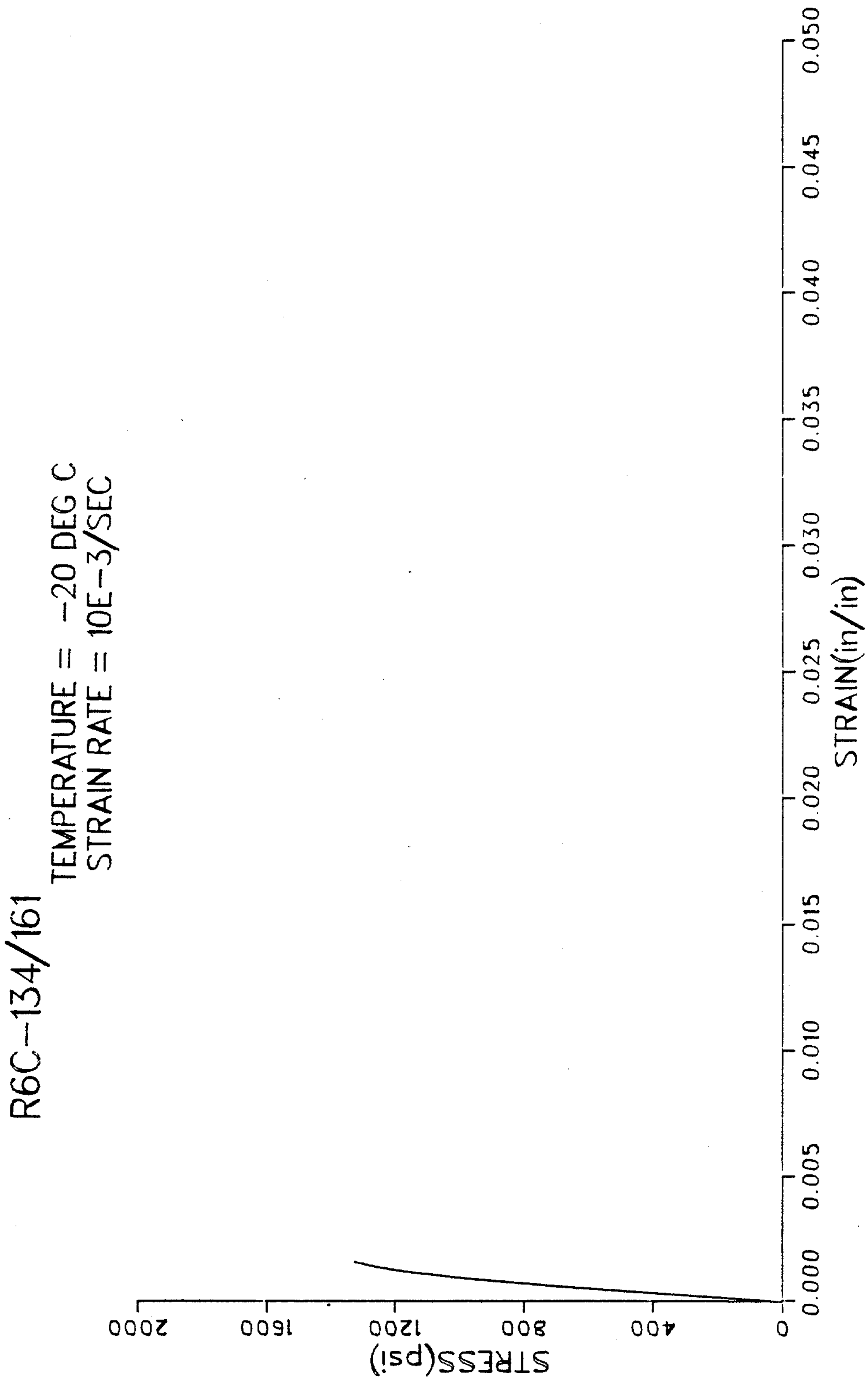

R1D-153/178
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

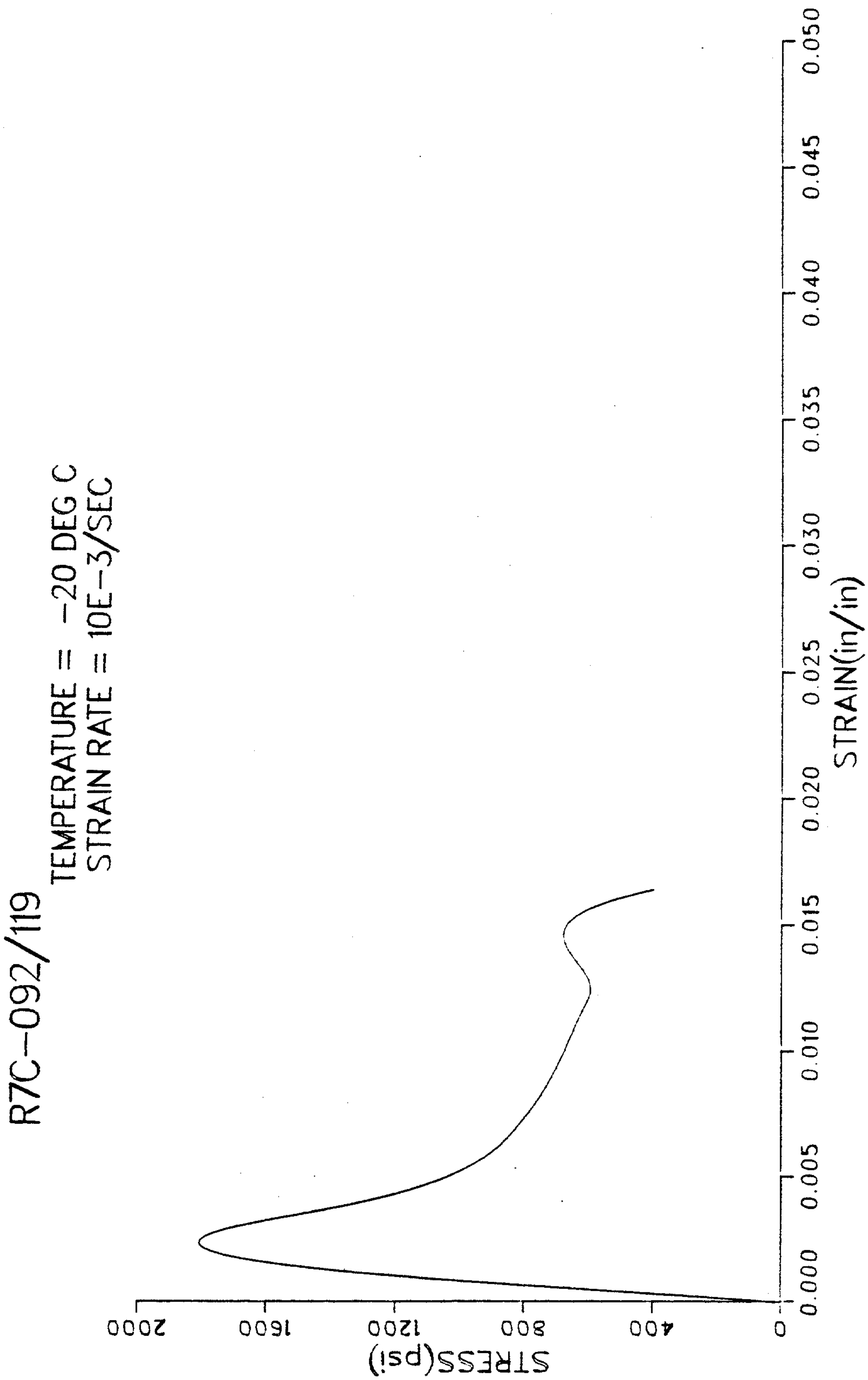

R2C-129/156
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

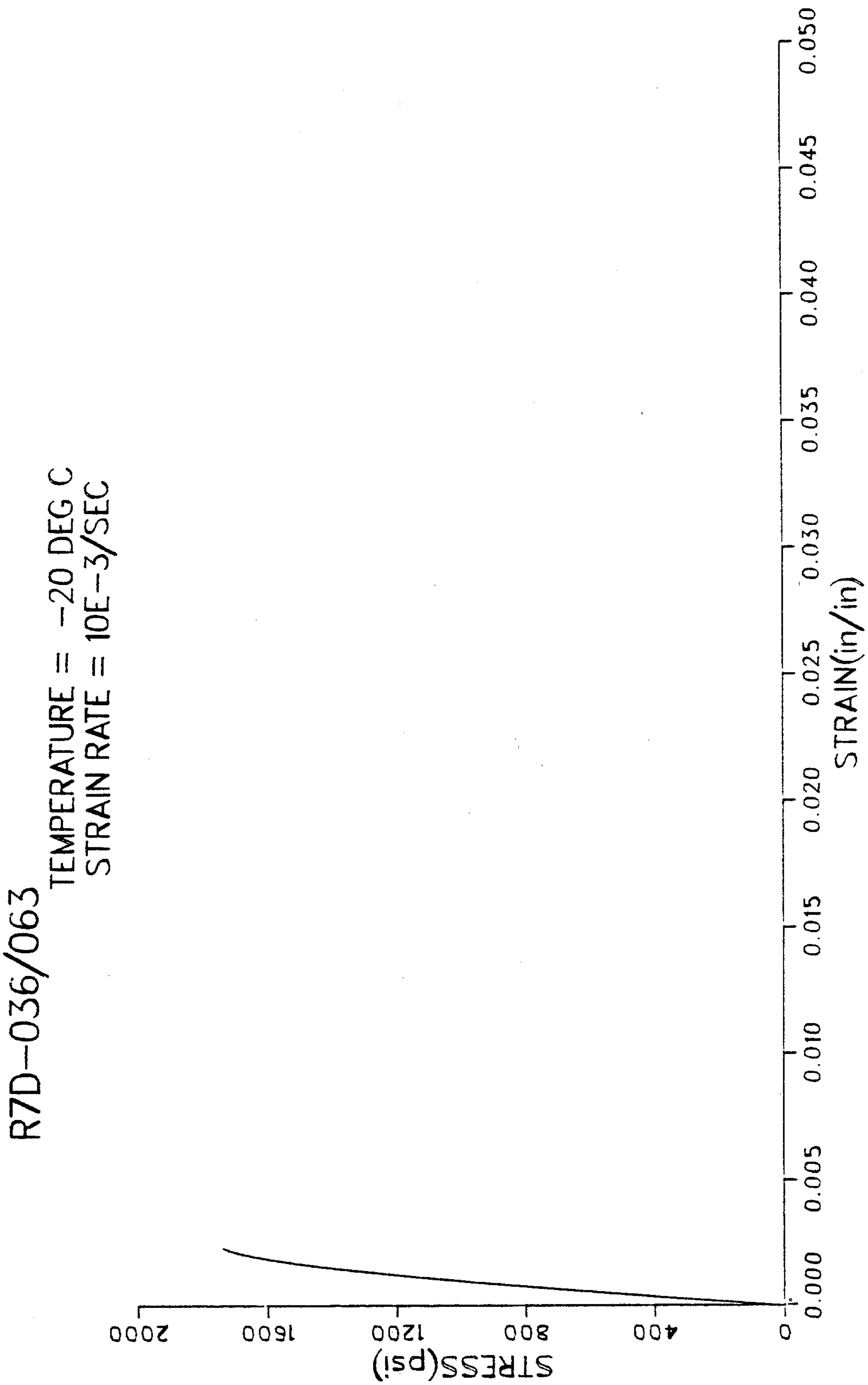

R2D-095/122
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

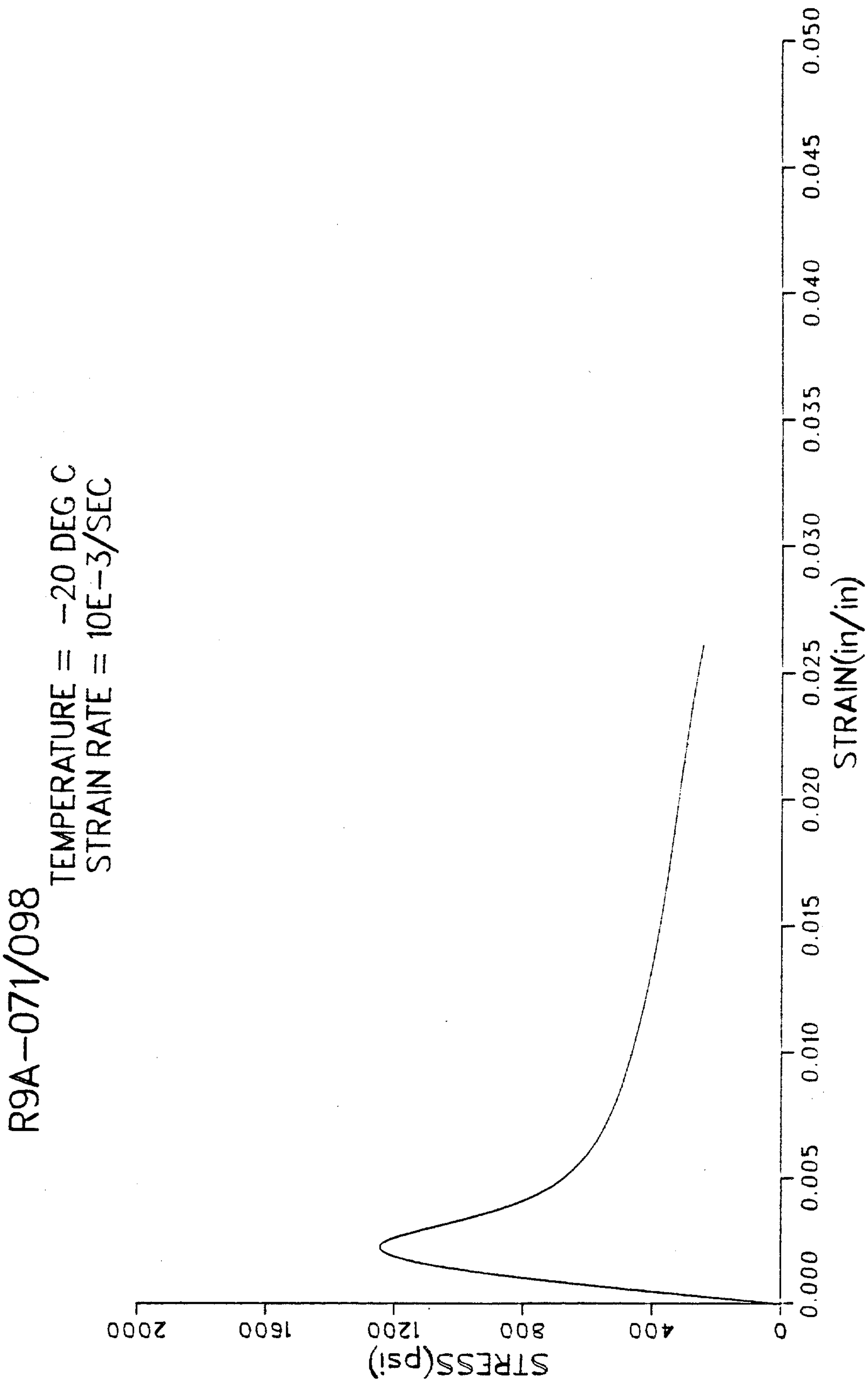

R4D-198/225
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

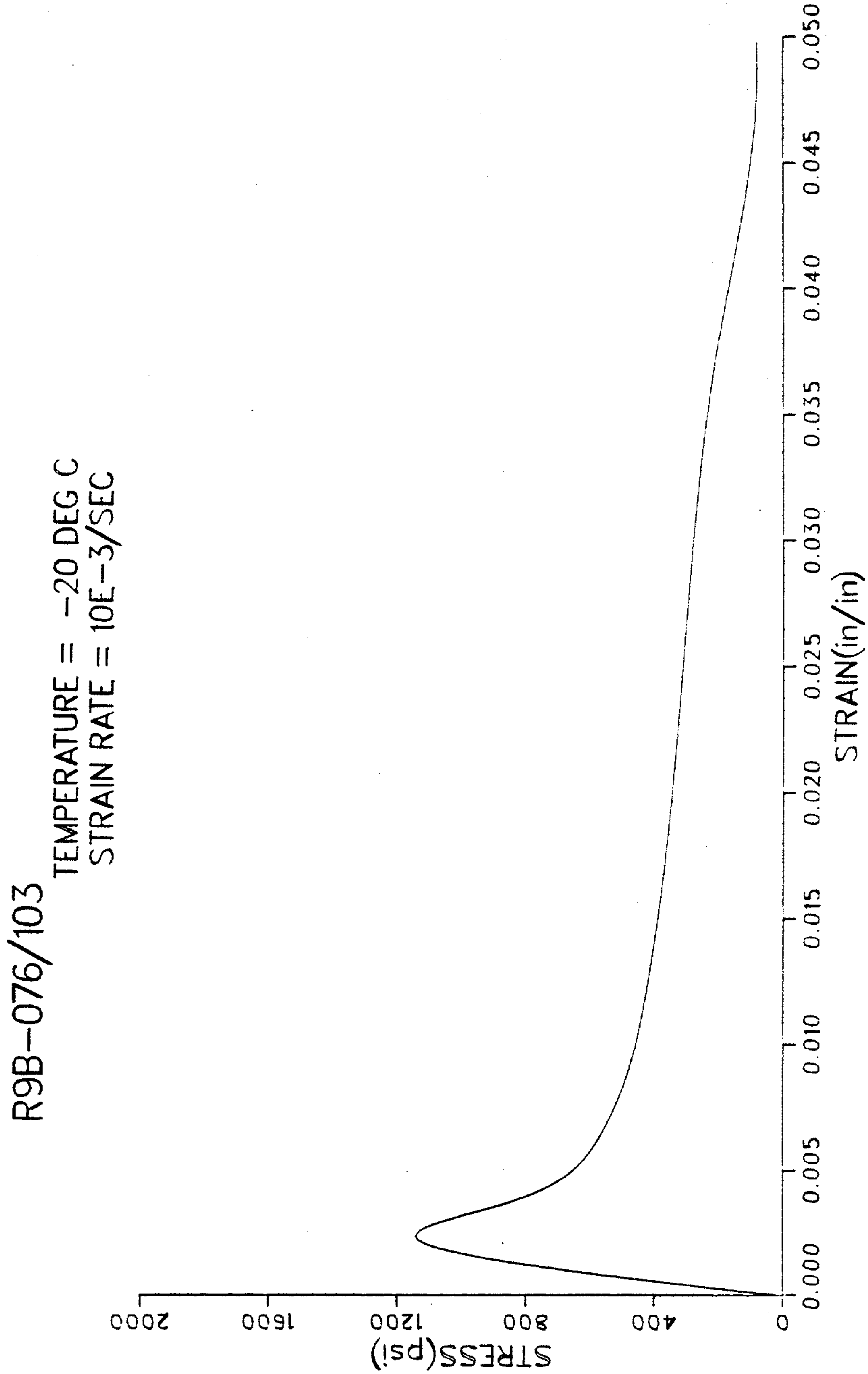

R6A-531/558
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
400
800
1200
1600
2000


R6C–134/161
TEMPERATURE = –20 DEG C
STRAIN RATE = 10E–3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

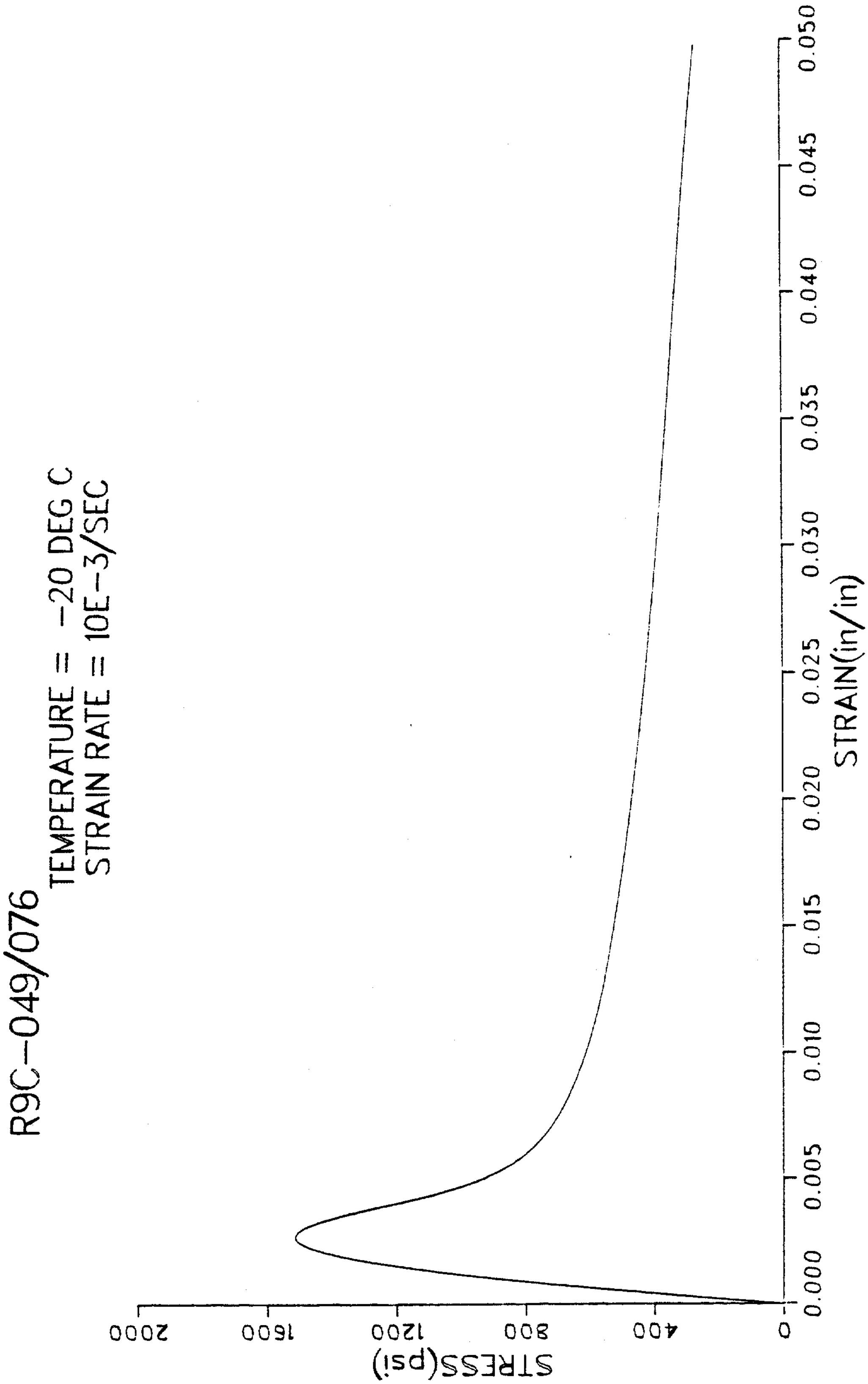

R7C-092/119
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

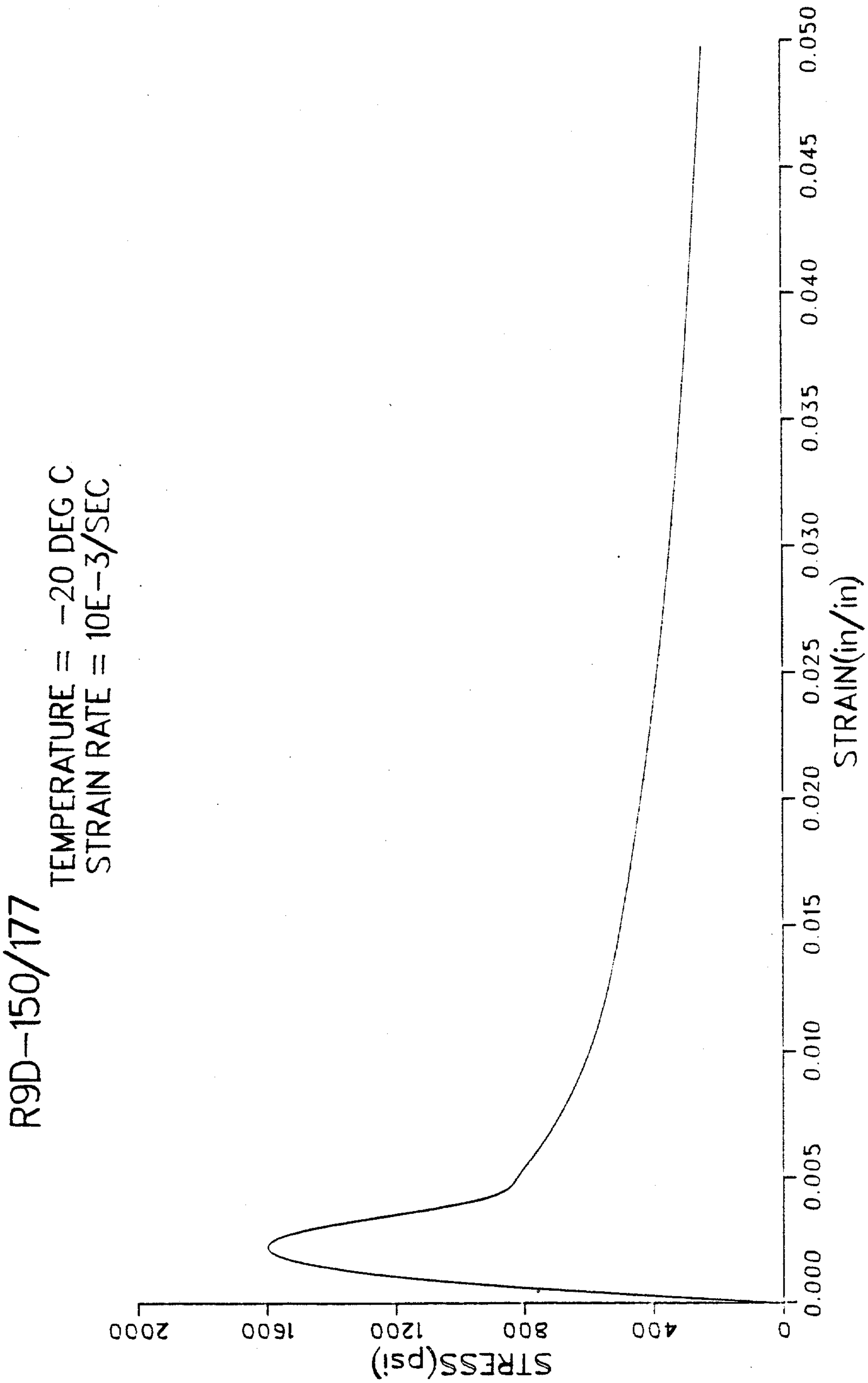

R7D-036/063
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

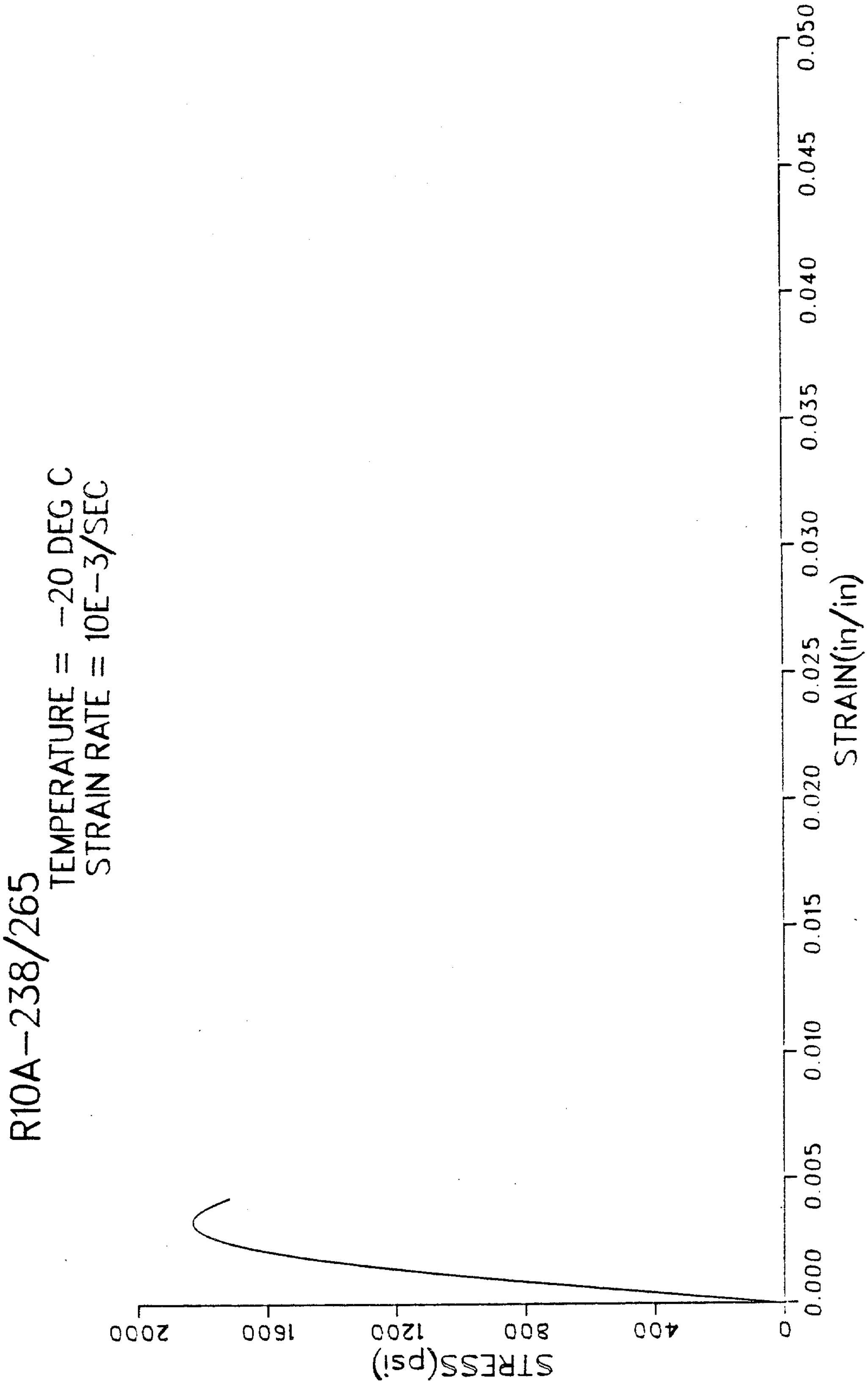

R9A-071/098
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

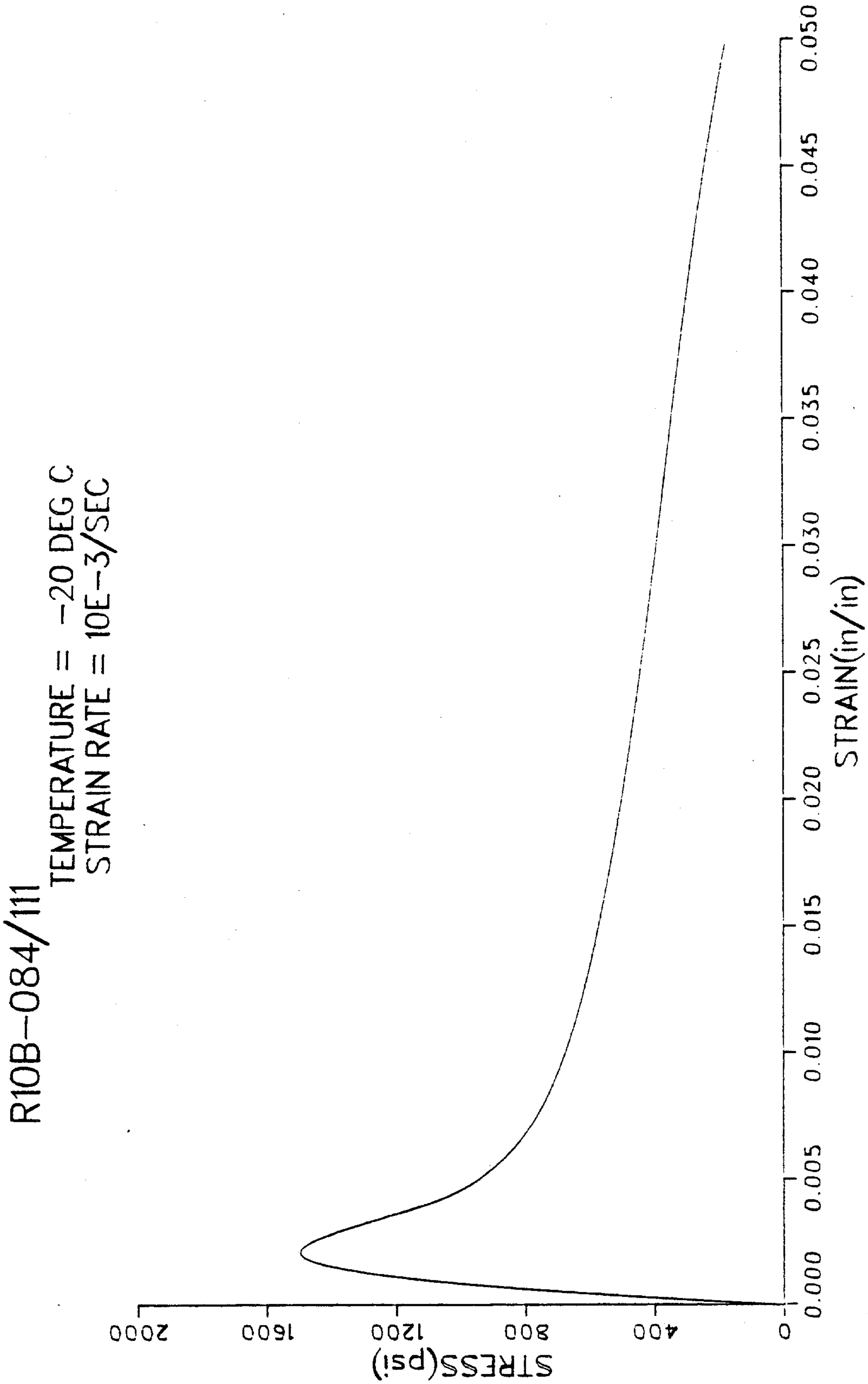

R9B-076/103
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

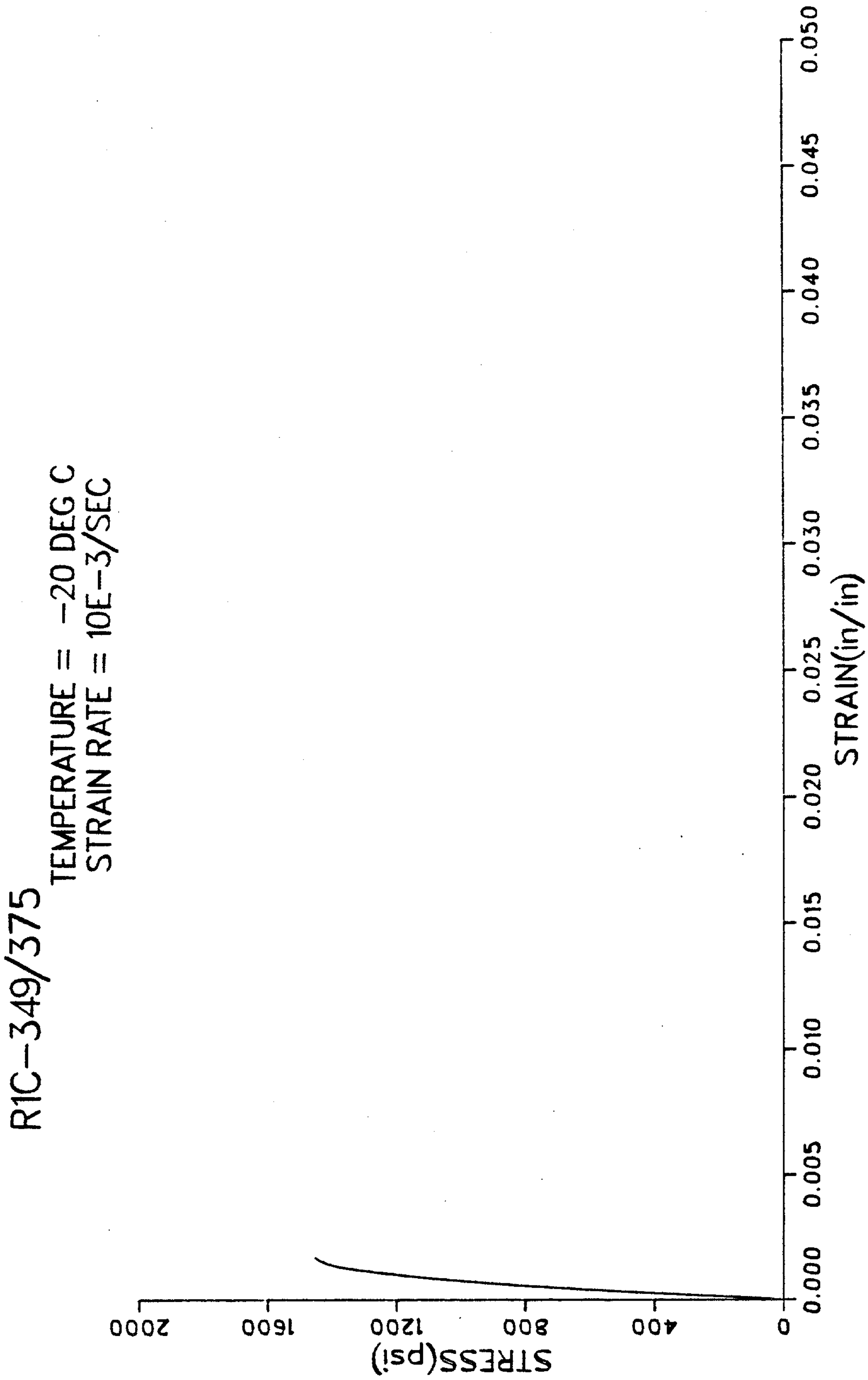
C-198
BRC 45-85

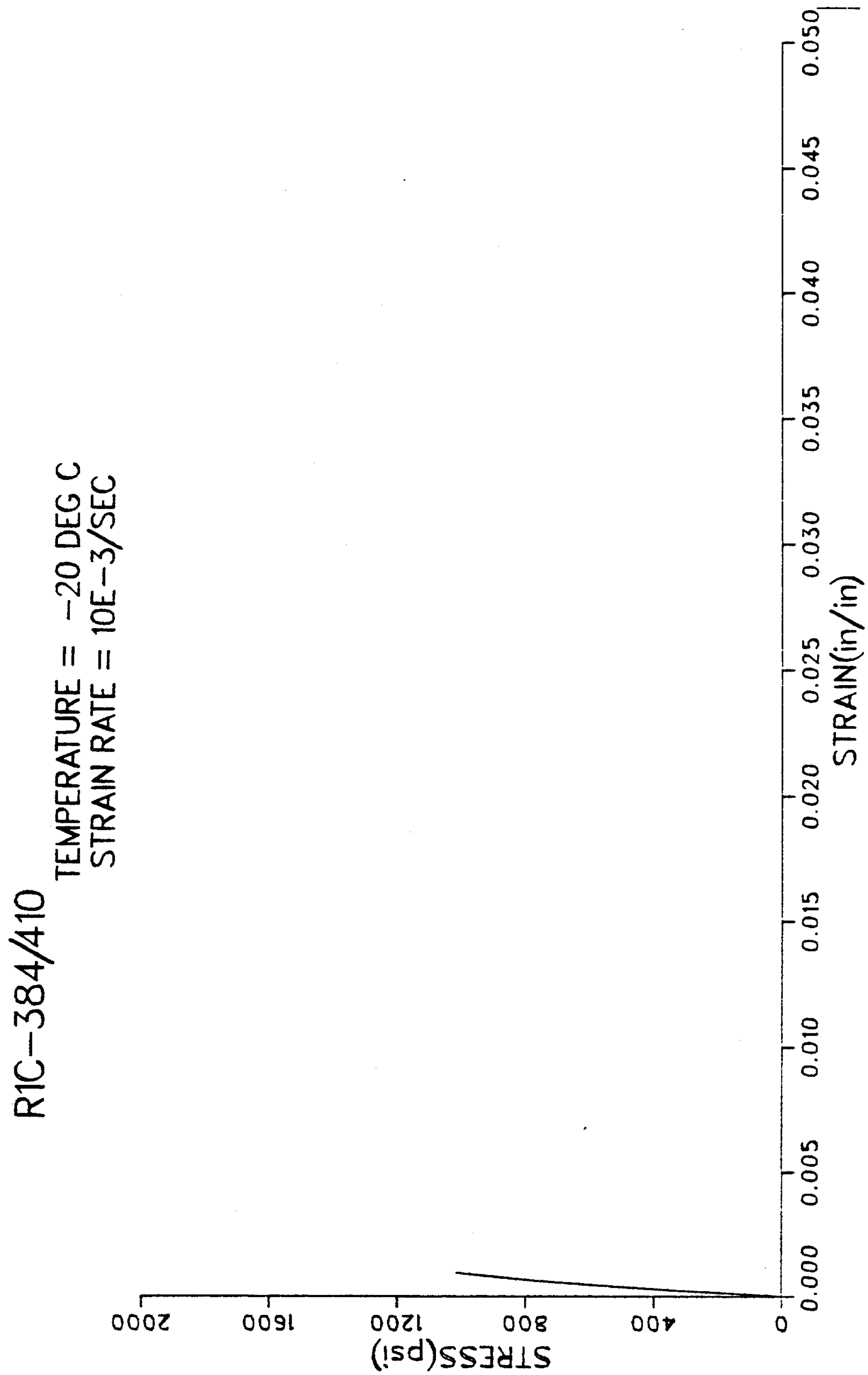


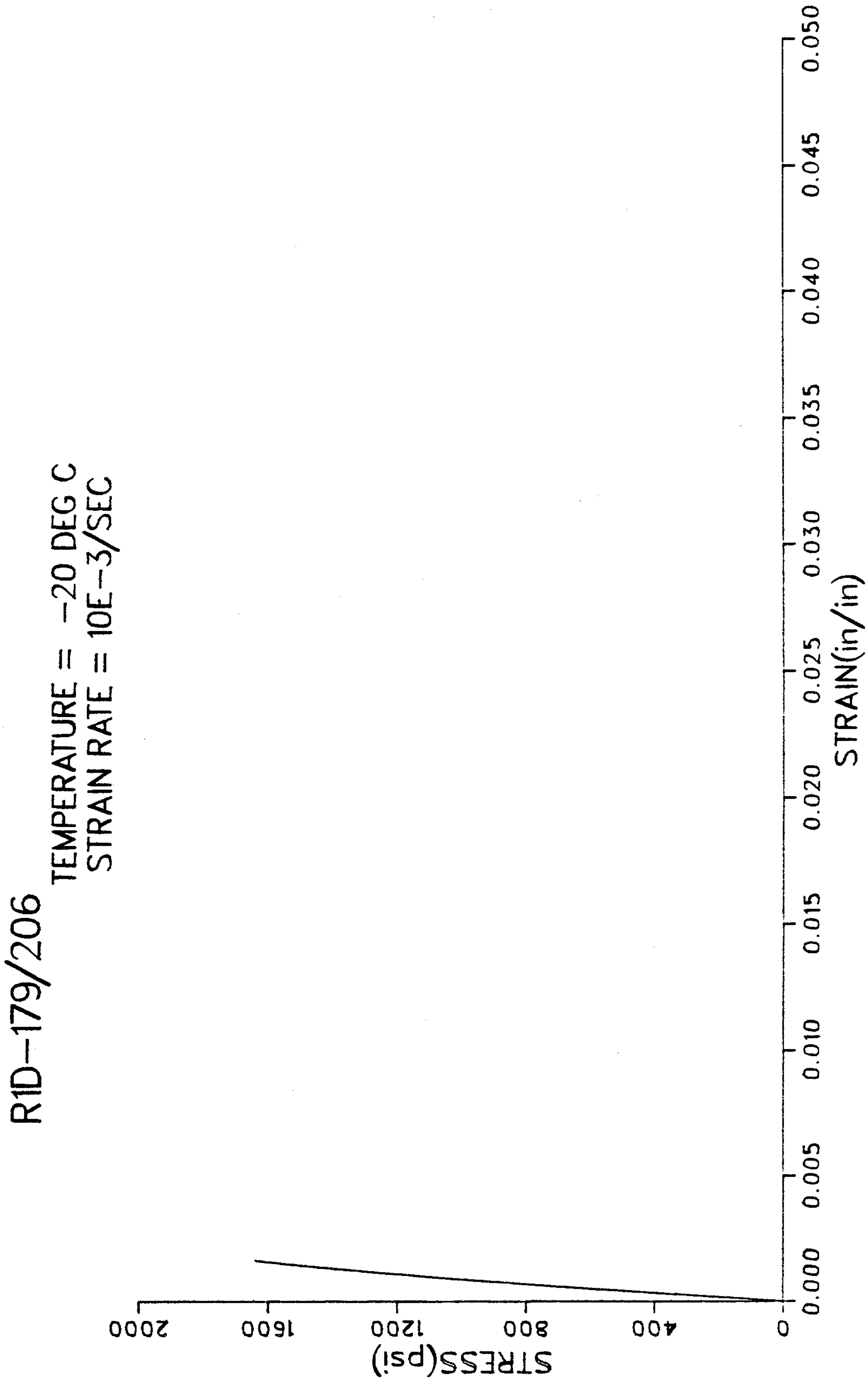

R9D-150/177
TEMPERATURE = −20 DEG C
STRAIN RATE = 10E−3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

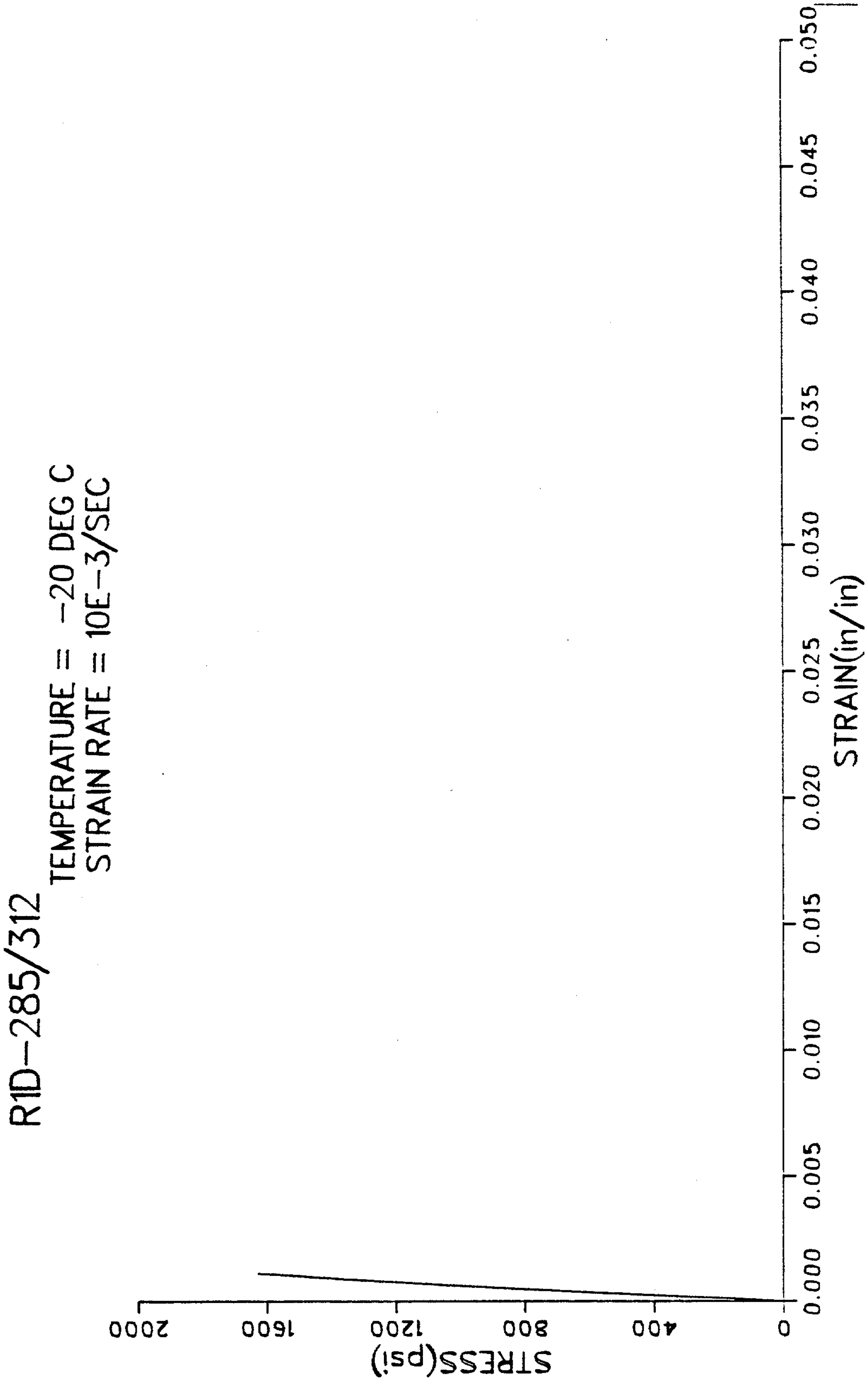

R10A-238/265
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

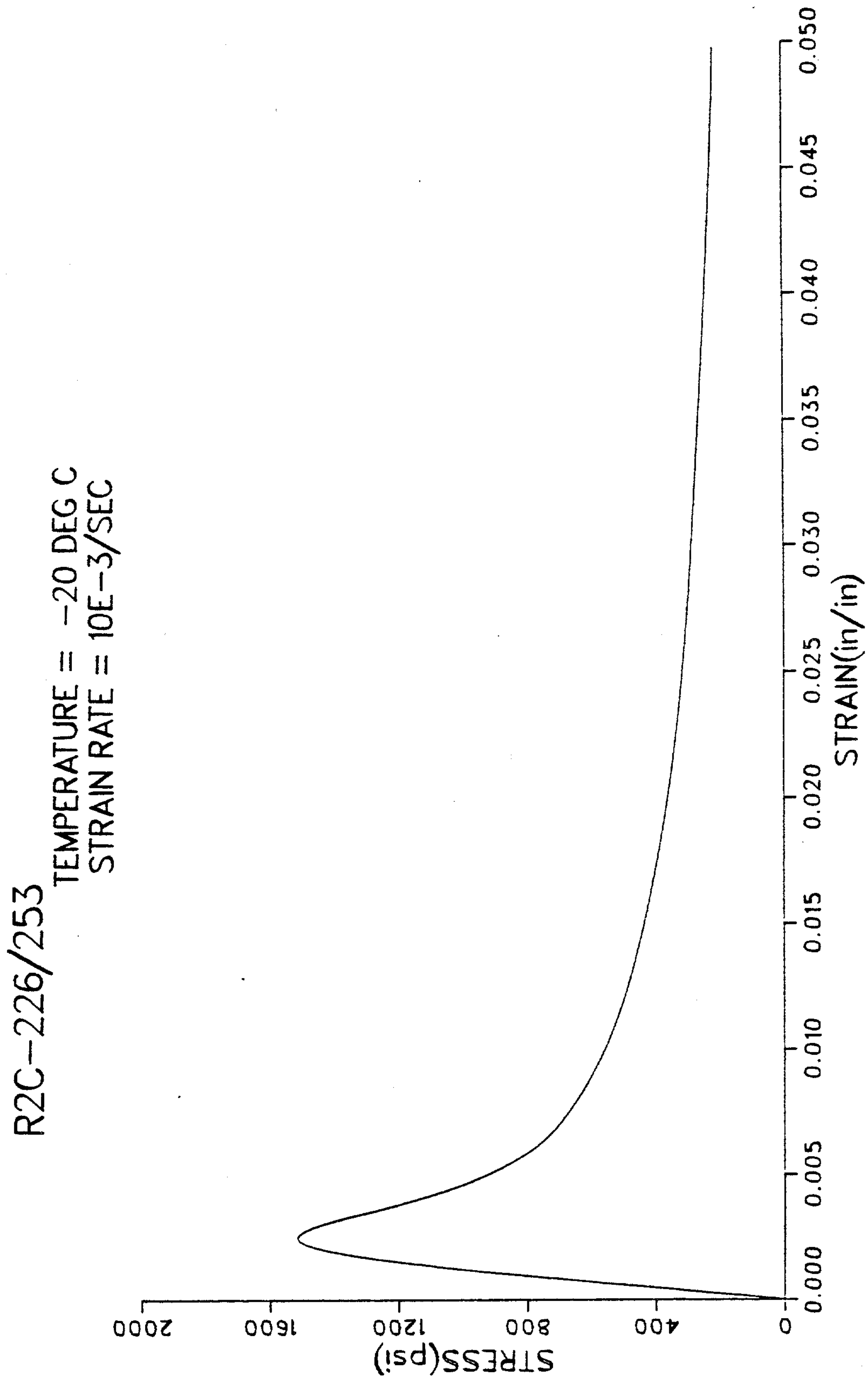

R10B-084/111
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

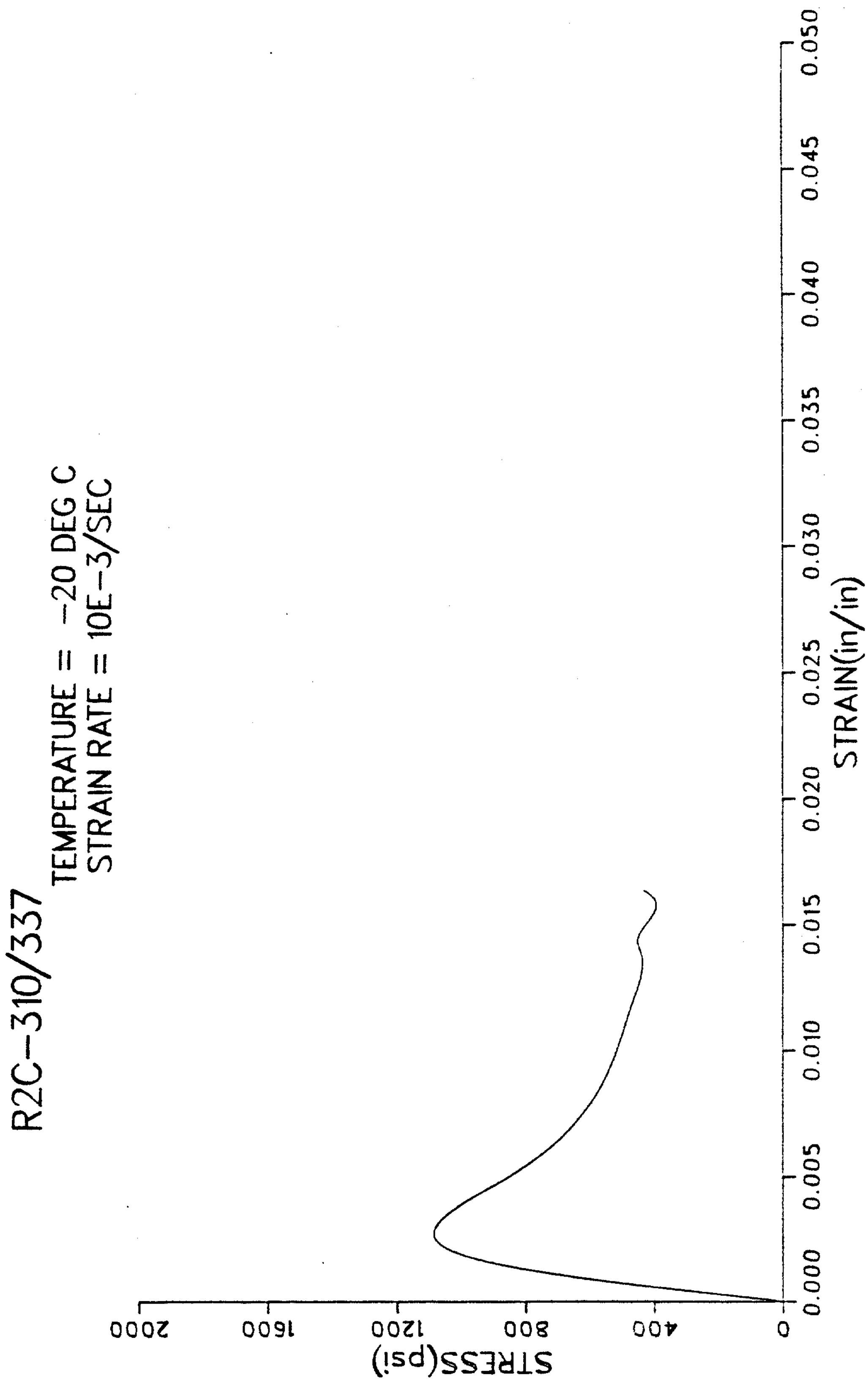

R1C-349/375
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000


R1C—384/410
TEMPERATURE = −20 DEG C
STRAIN RATE = 10E−3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

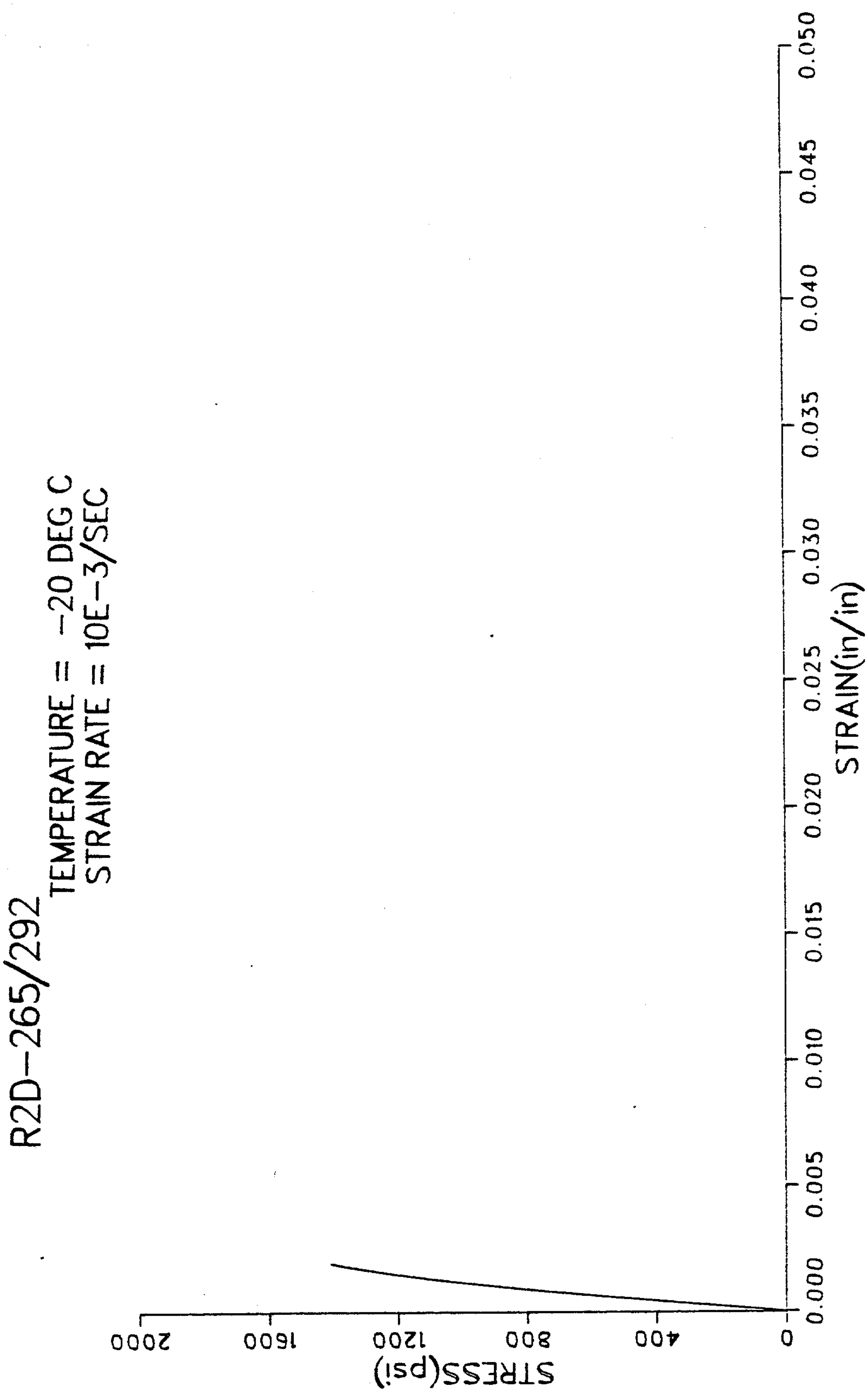

R1D-179/206
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000

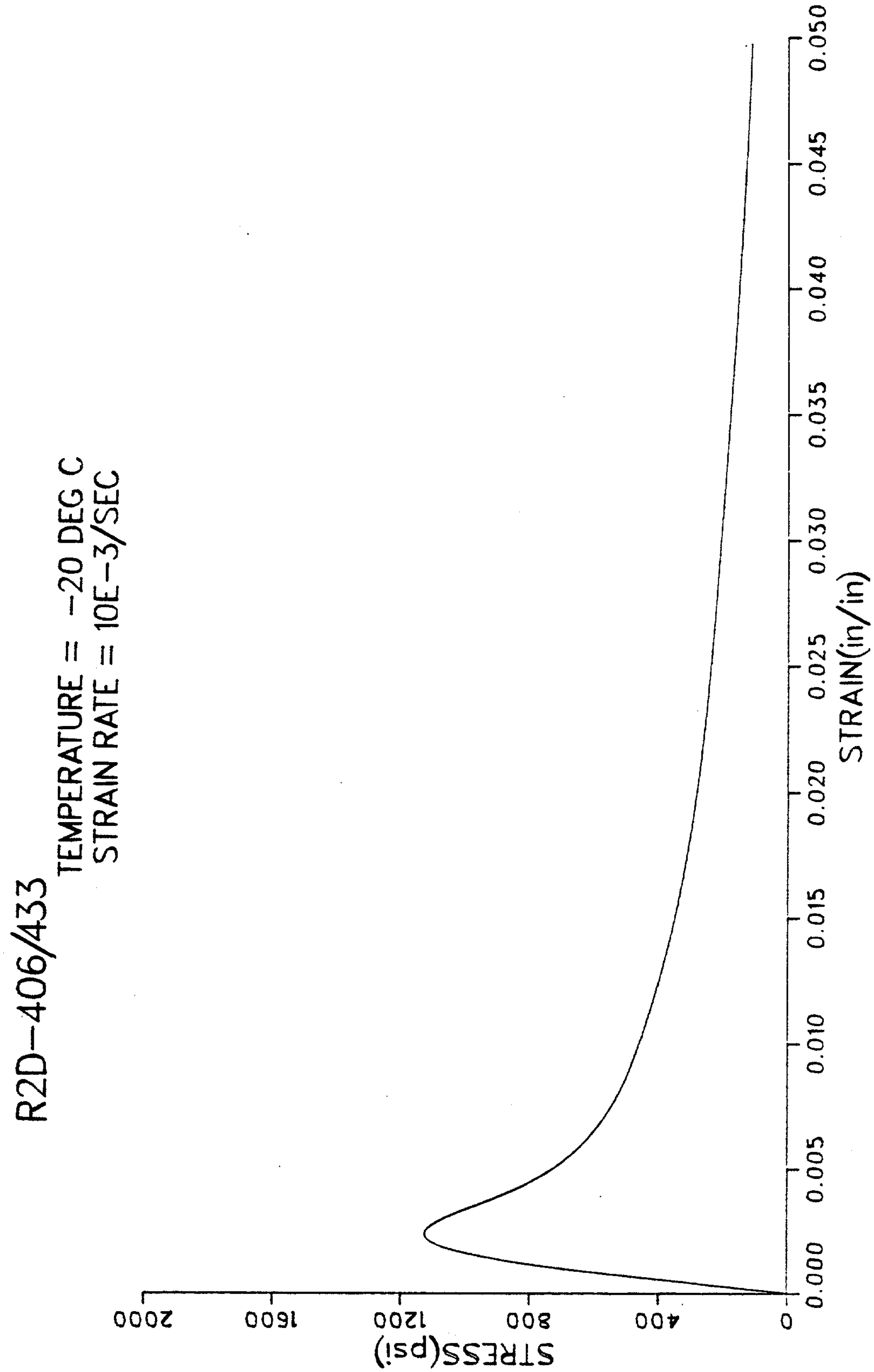

R1D-285/312
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000

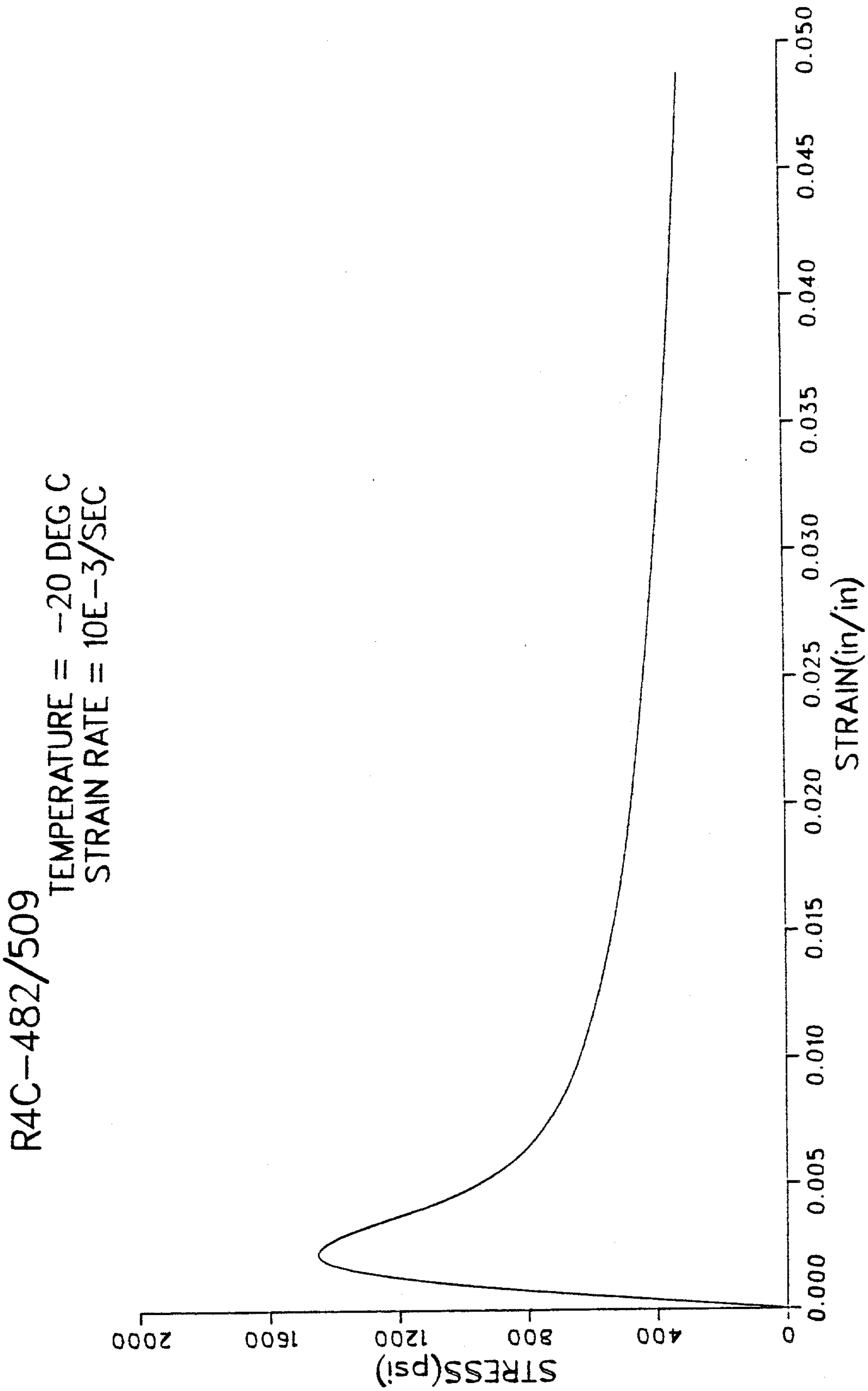

R2C-226/253
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

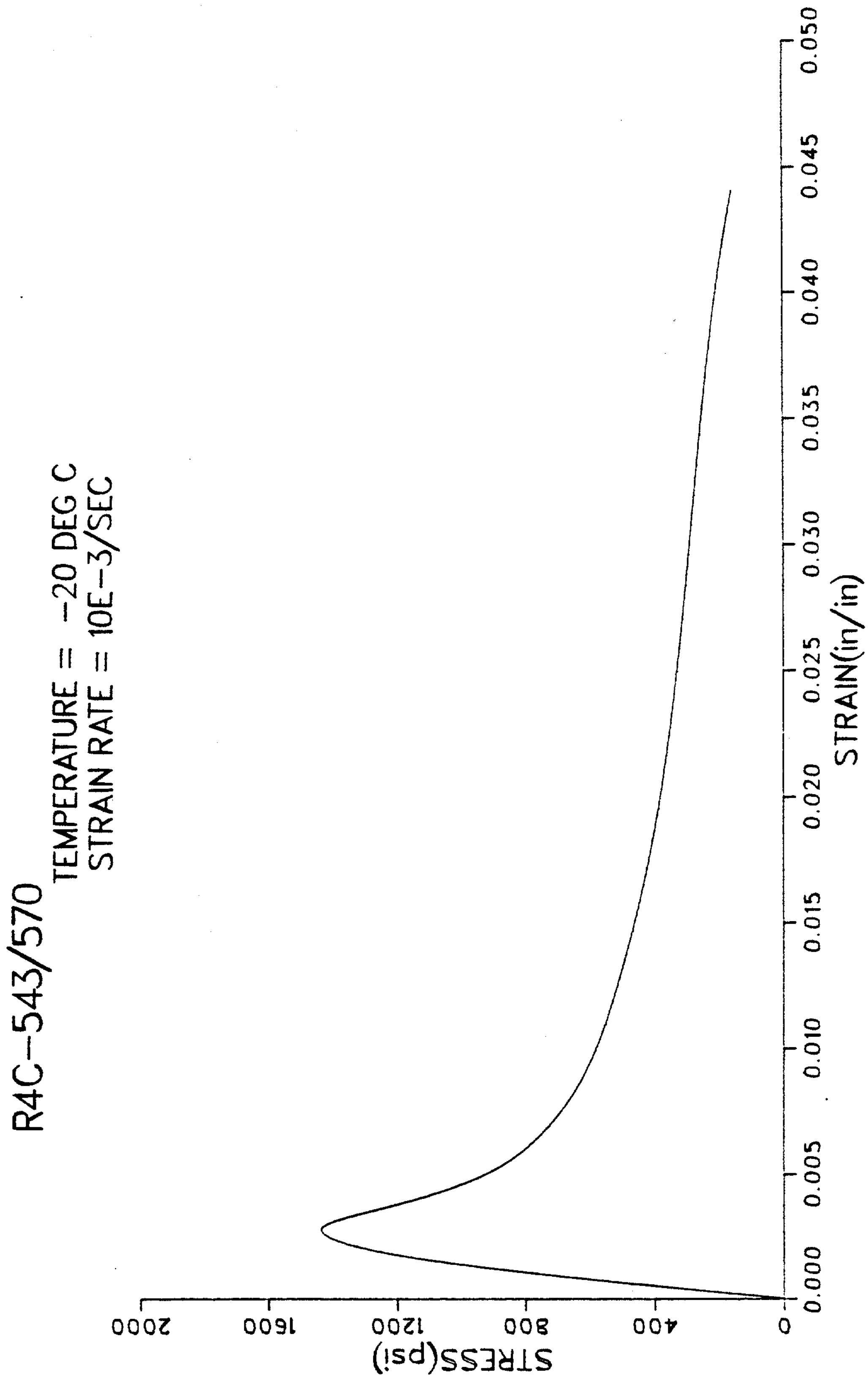

R2C-310/337
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

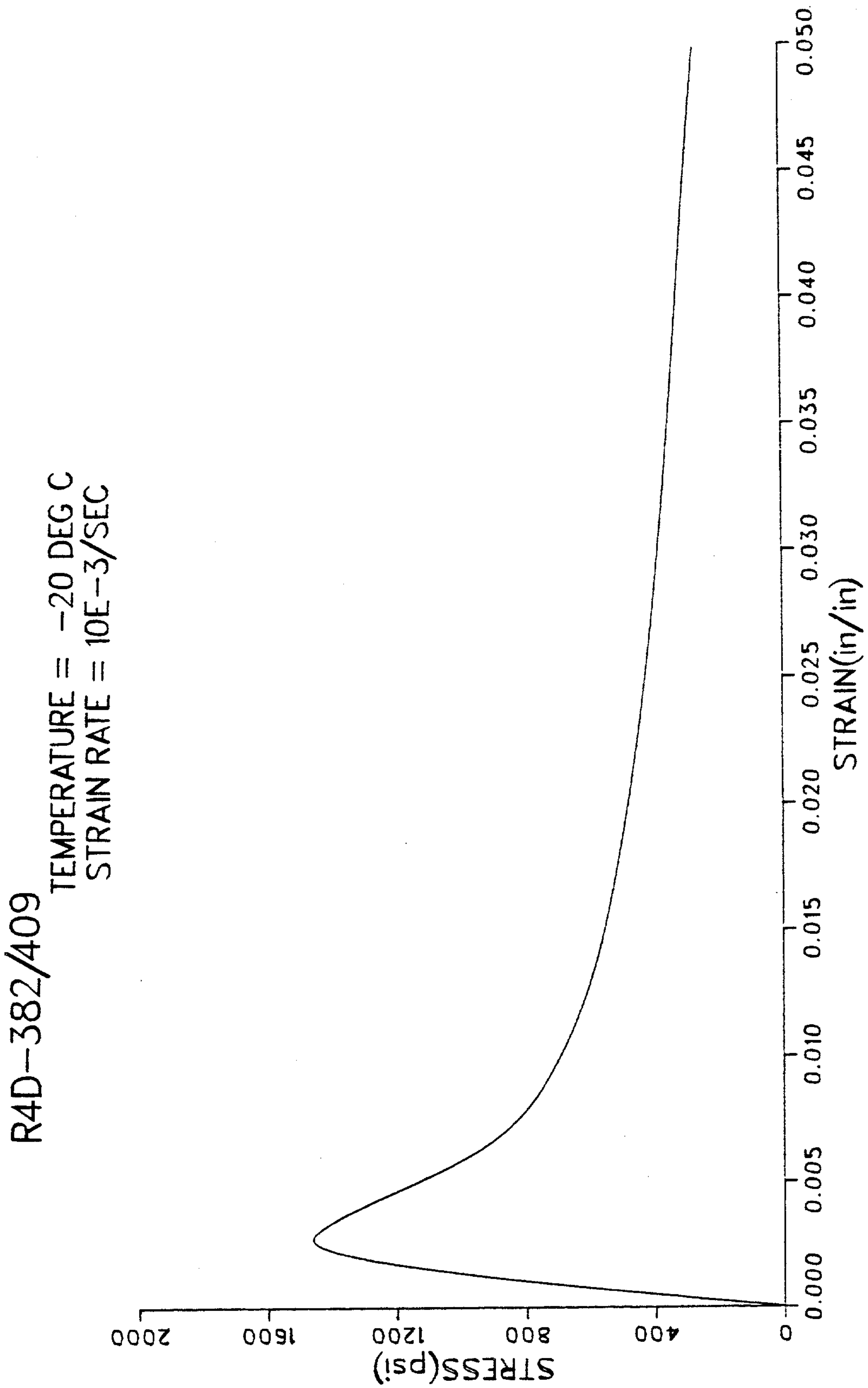
C-208
BRC 45-85

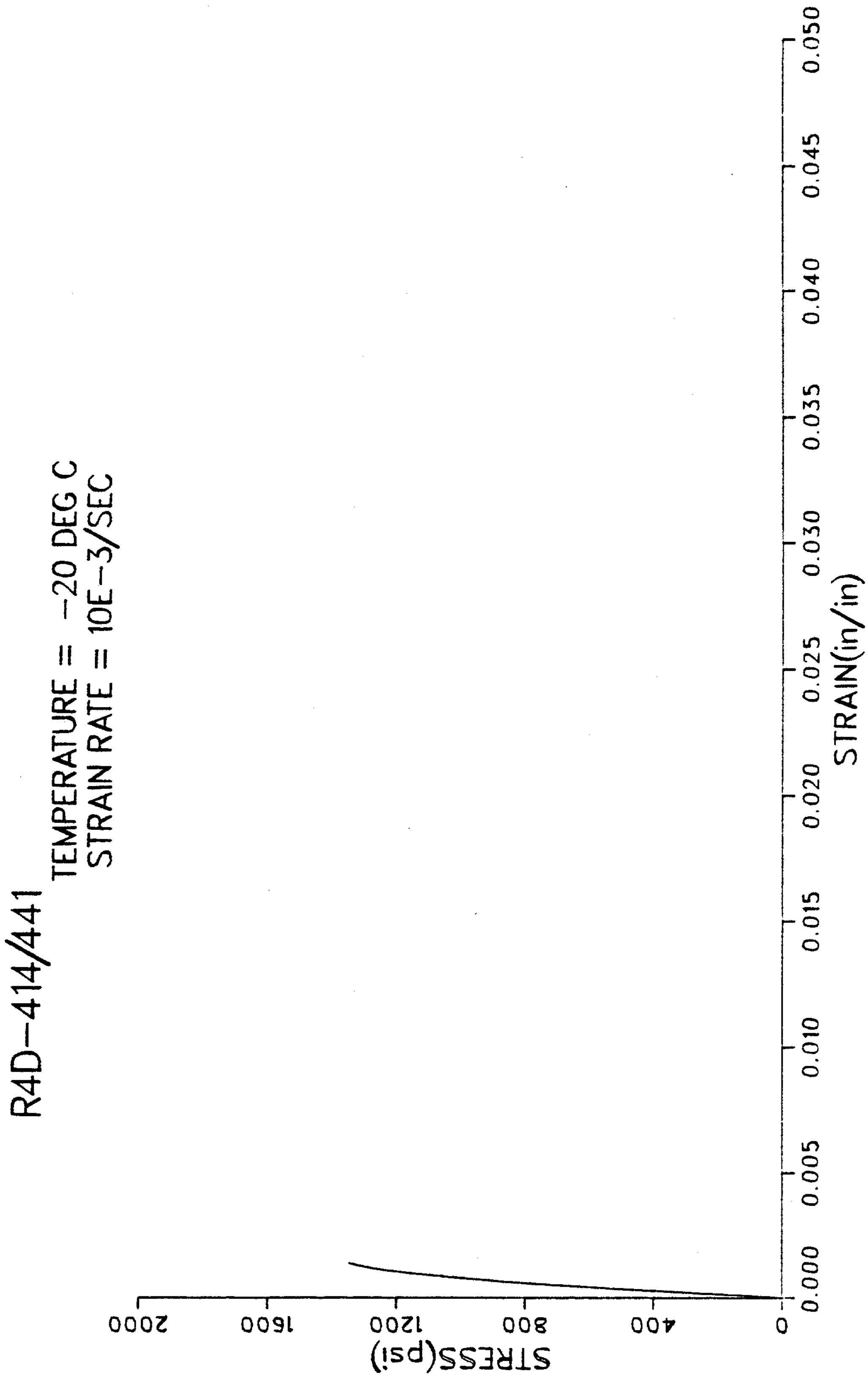


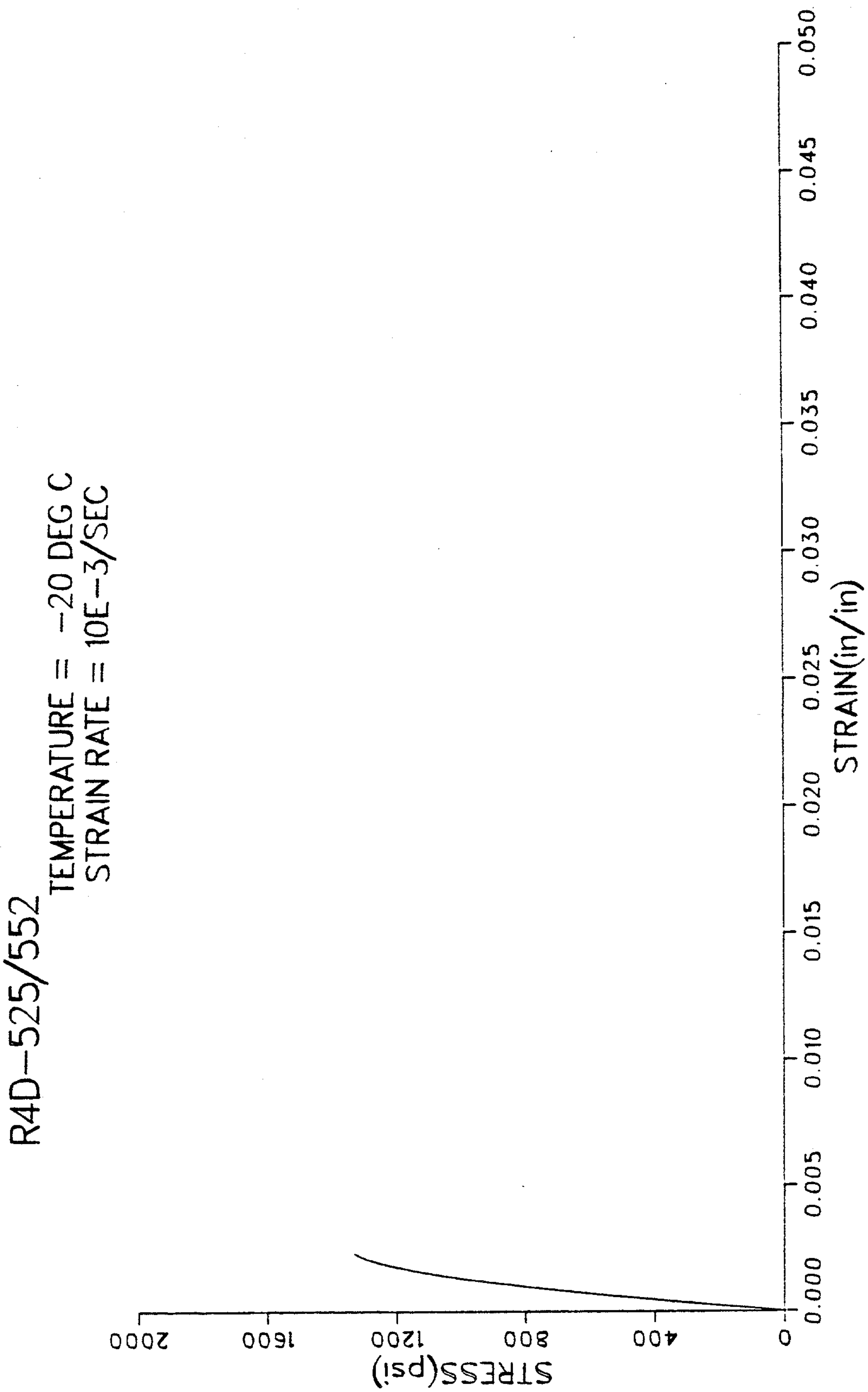

R2D-406/433
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

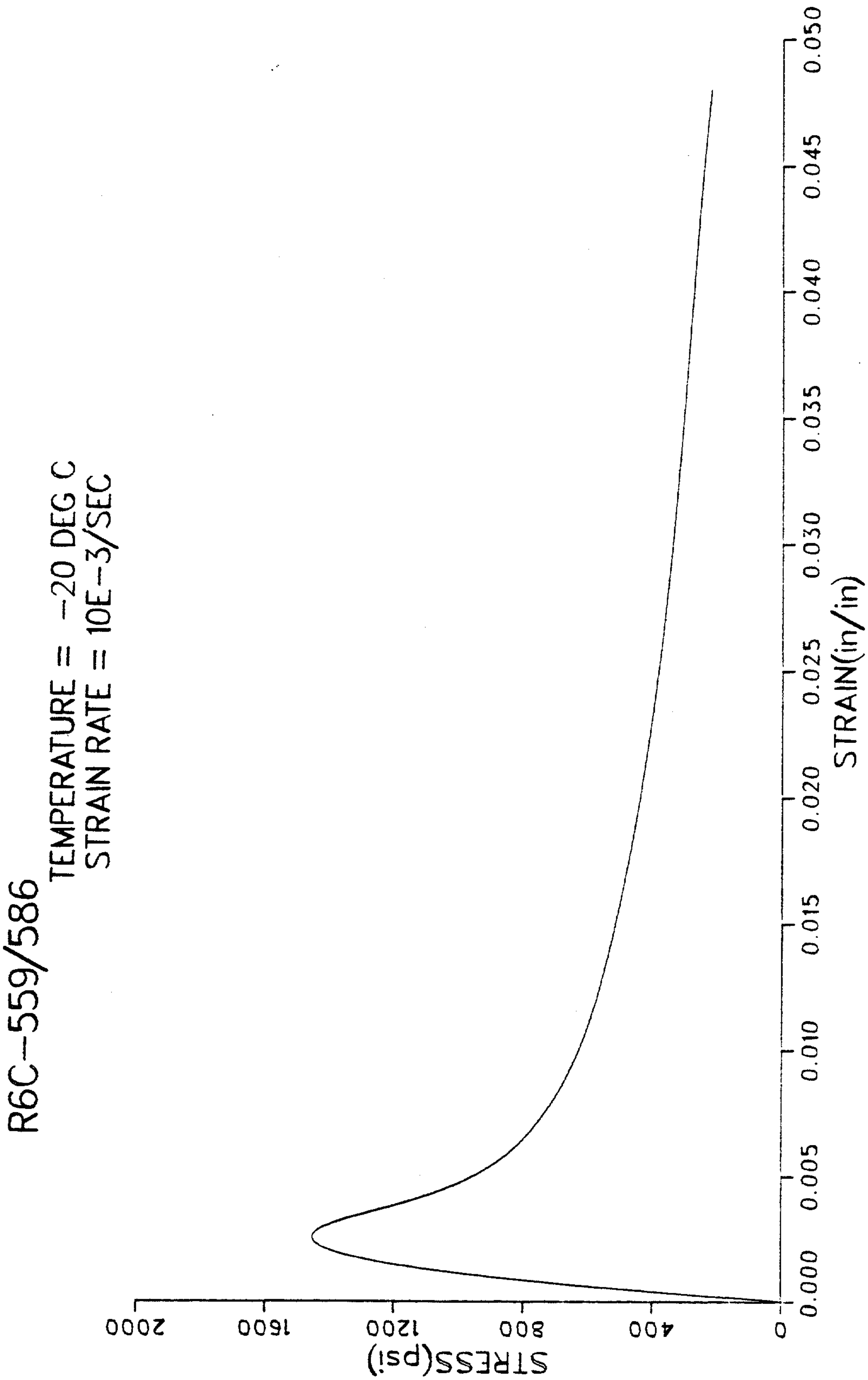

R4C-482/509
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
400
800
1200
1600
2000

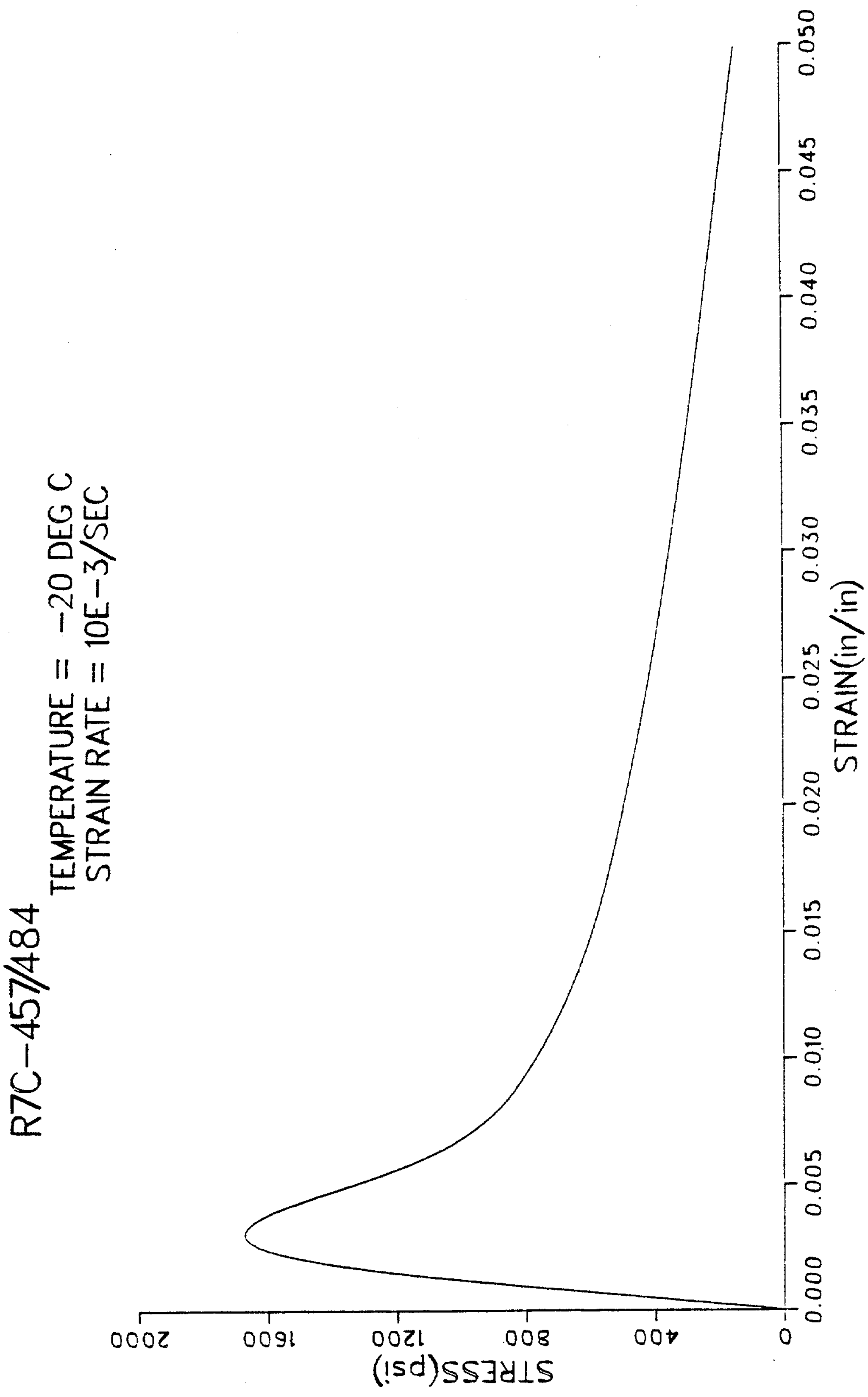

R4C-543/570
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

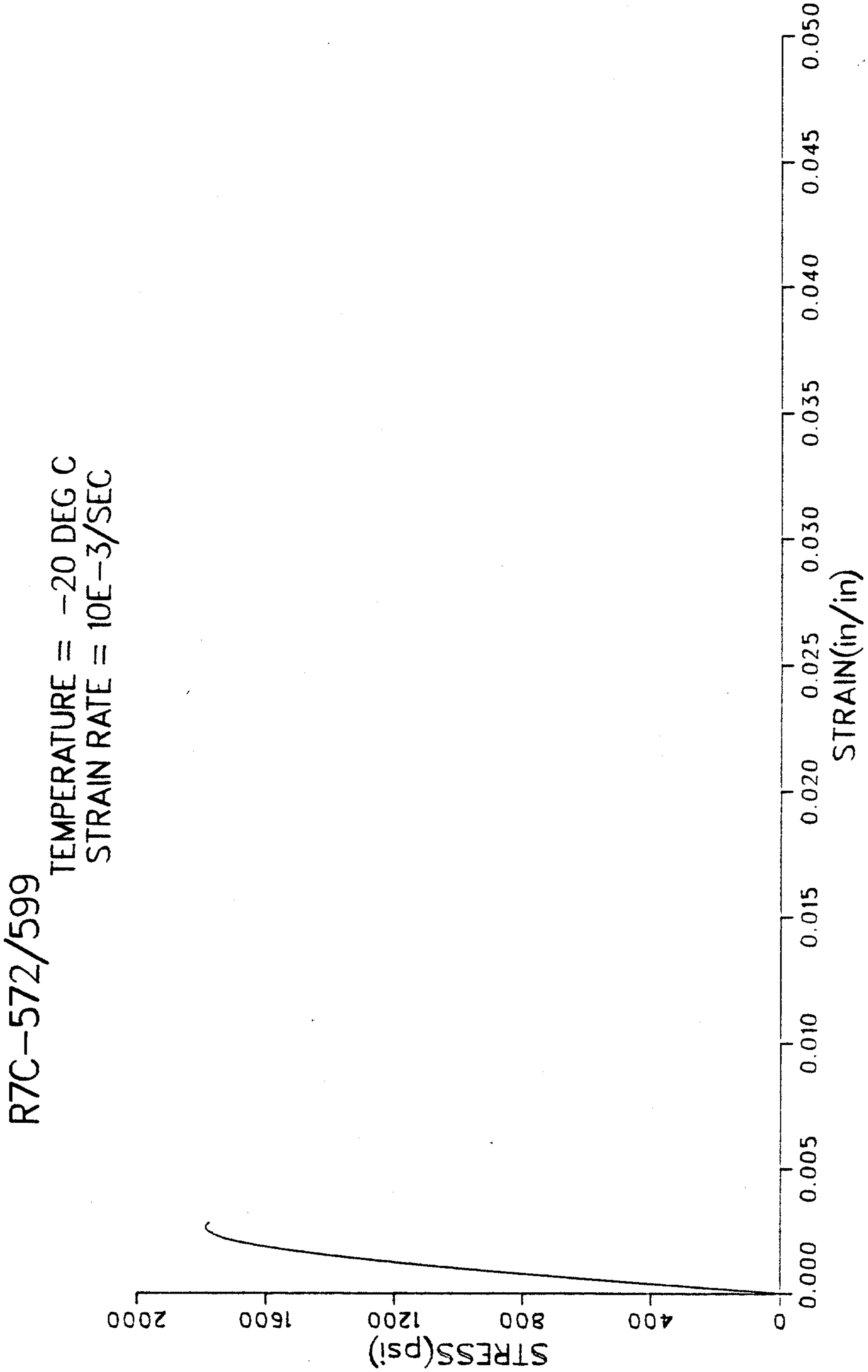

R4D-382/409
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

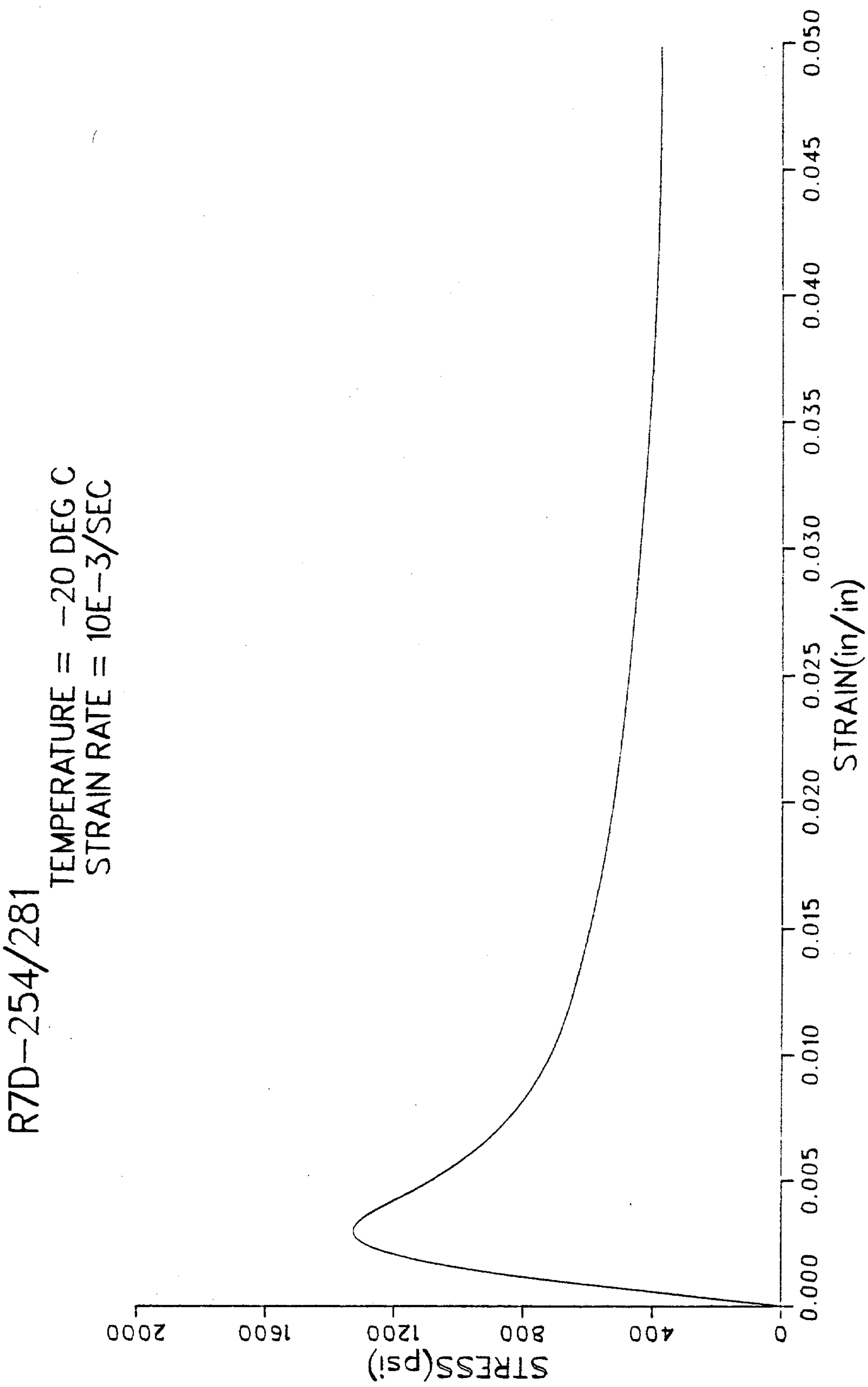

R4D-414/441
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

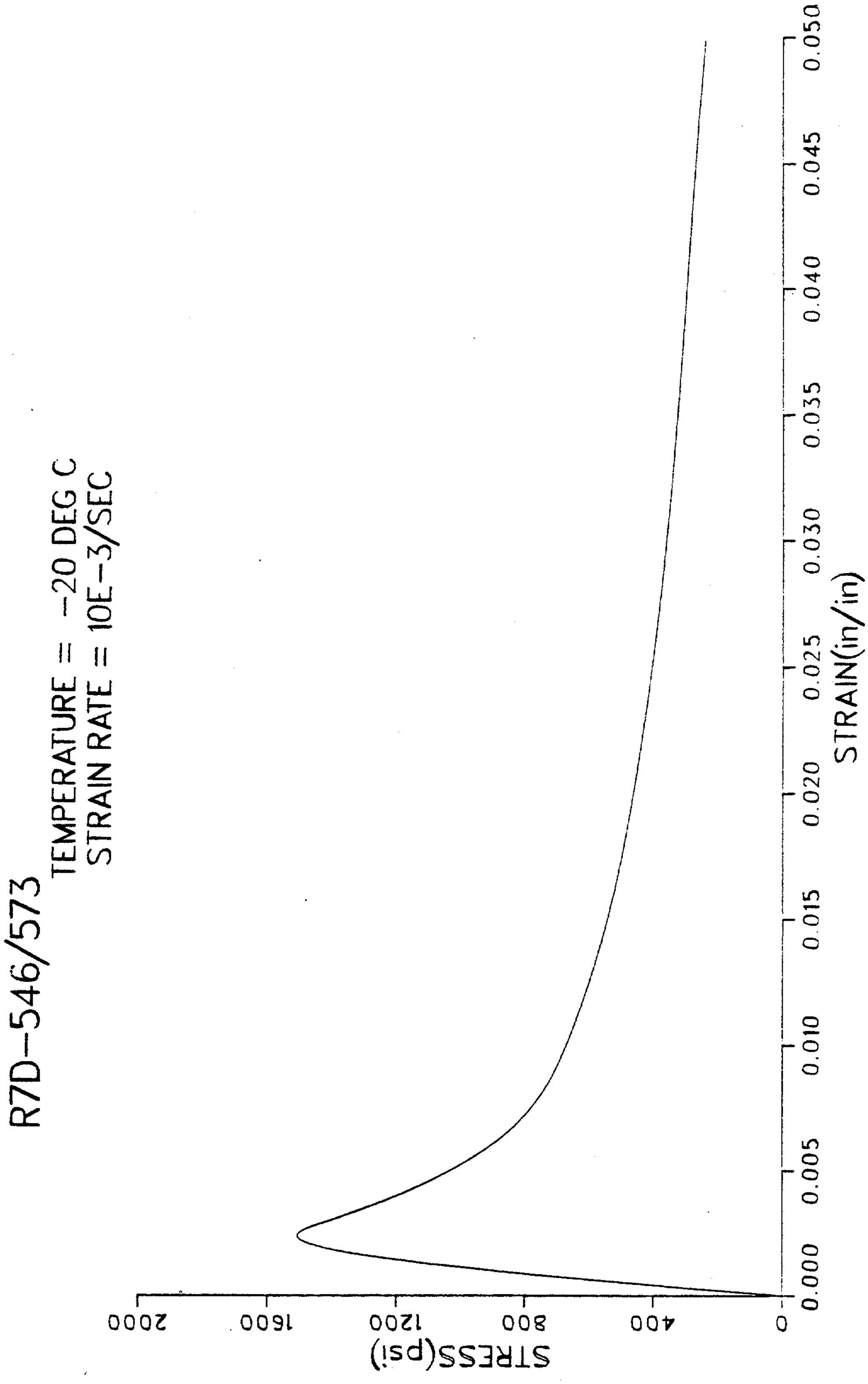

R4D-525/552
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

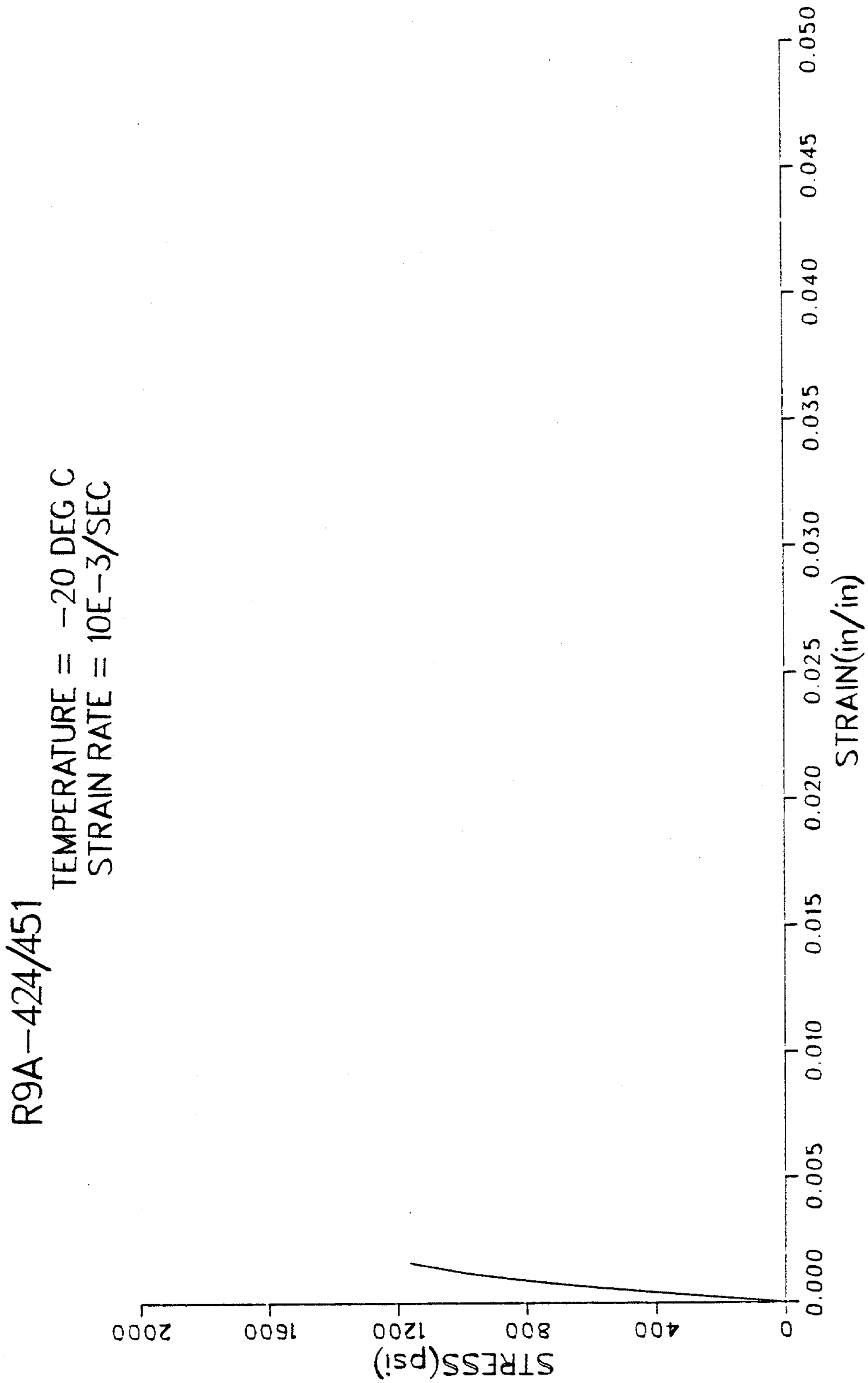

R6C–559/586
TEMPERATURE = –20 DEG C
STRAIN RATE = 10E–3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

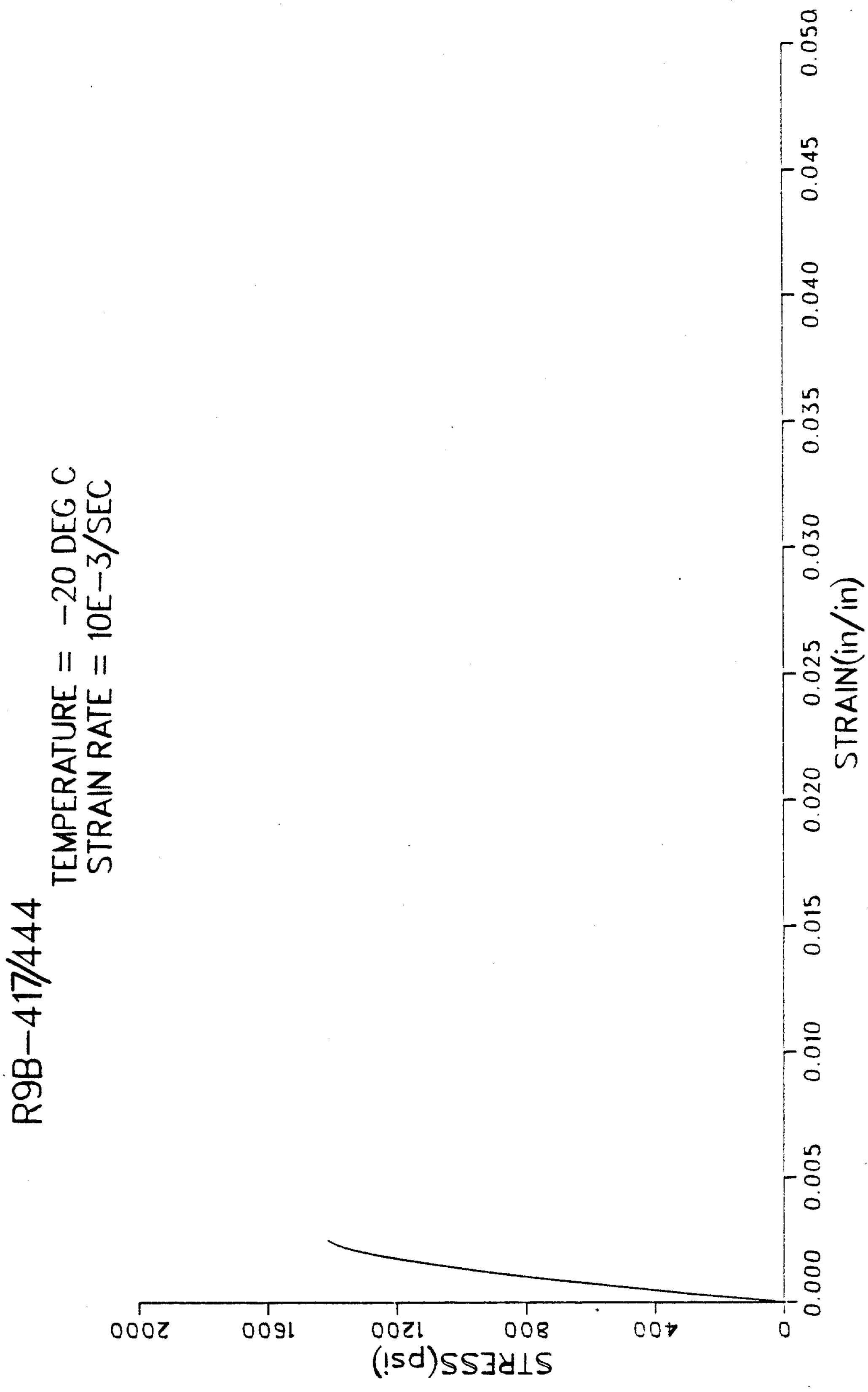

R7C-457/484
TEMPERATURE = −20 DEG C
STRAIN RATE = 10E−3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

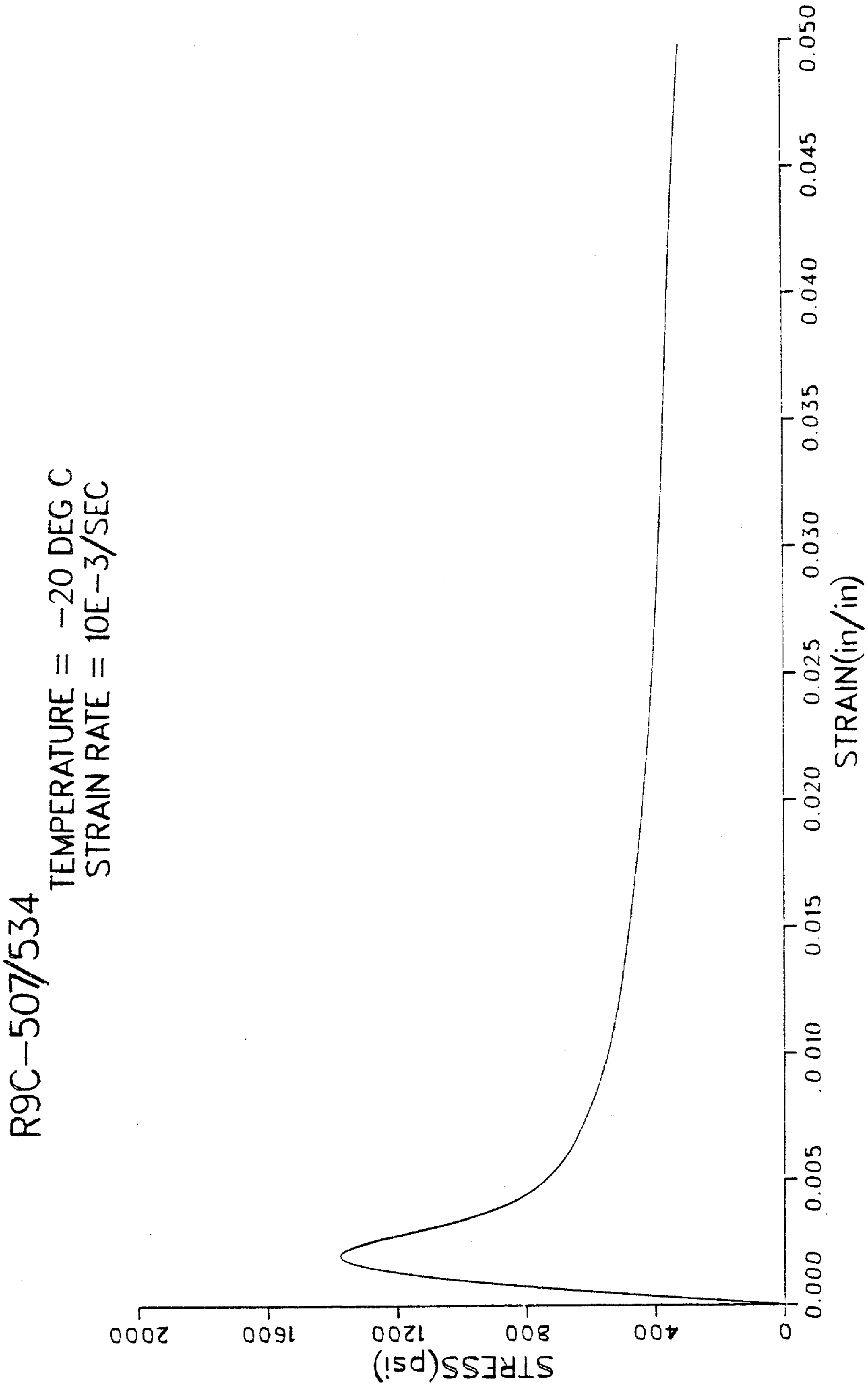

R7C-572/599
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

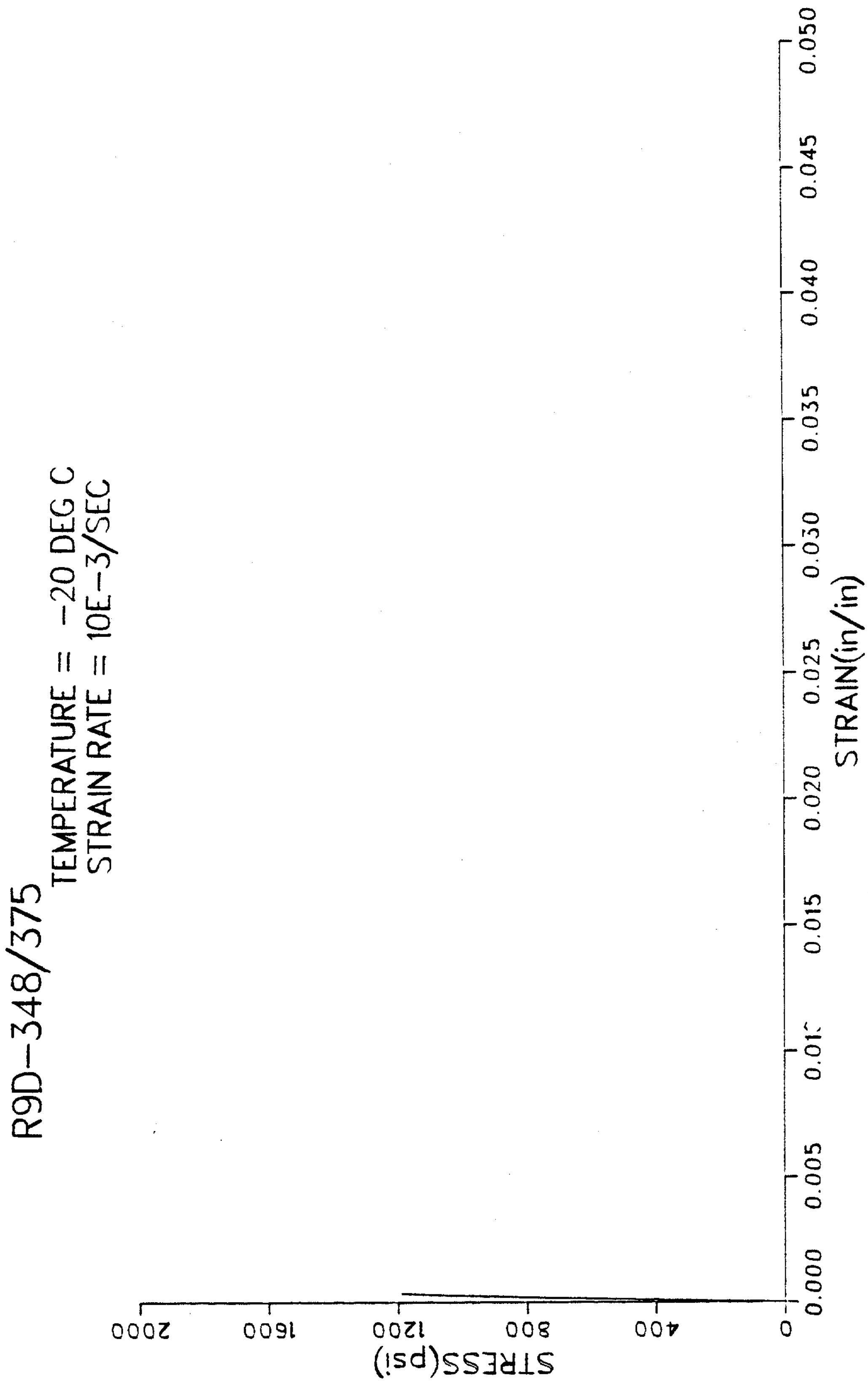

R7D-254/281
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

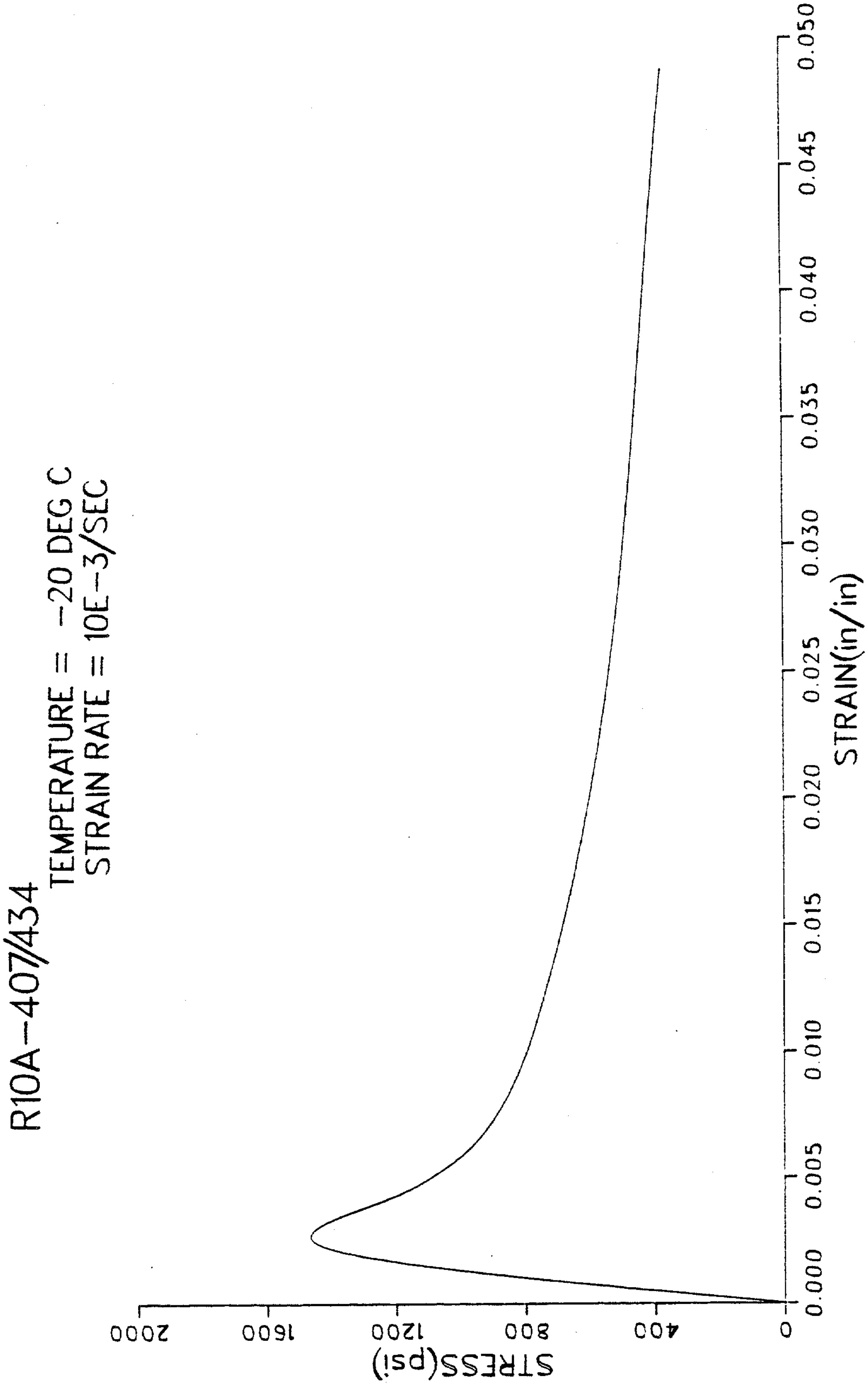

R7D–546/573
TEMPERATURE = –20 DEG C
STRAIN RATE = 10E–3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

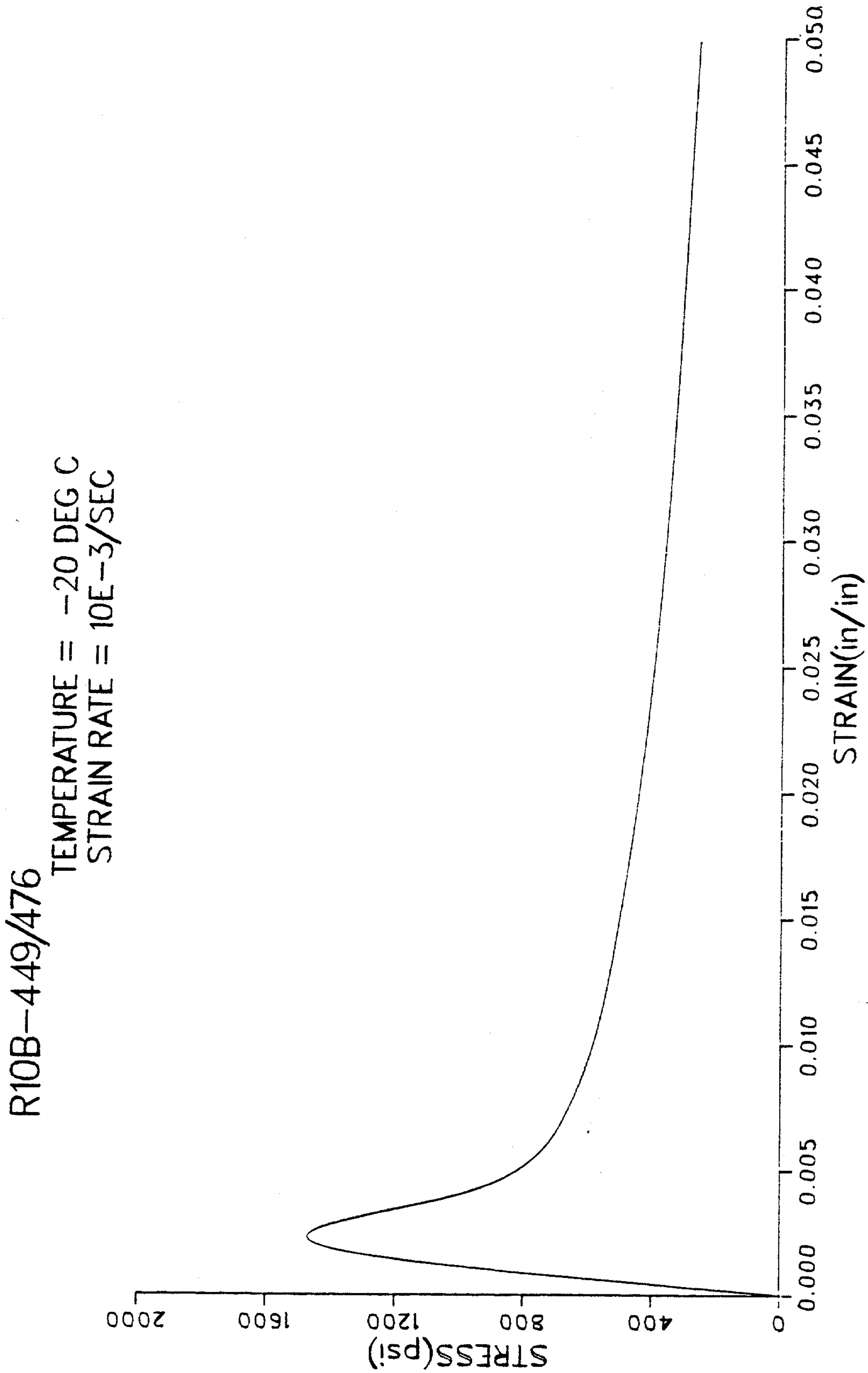

R9A-424/451
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000

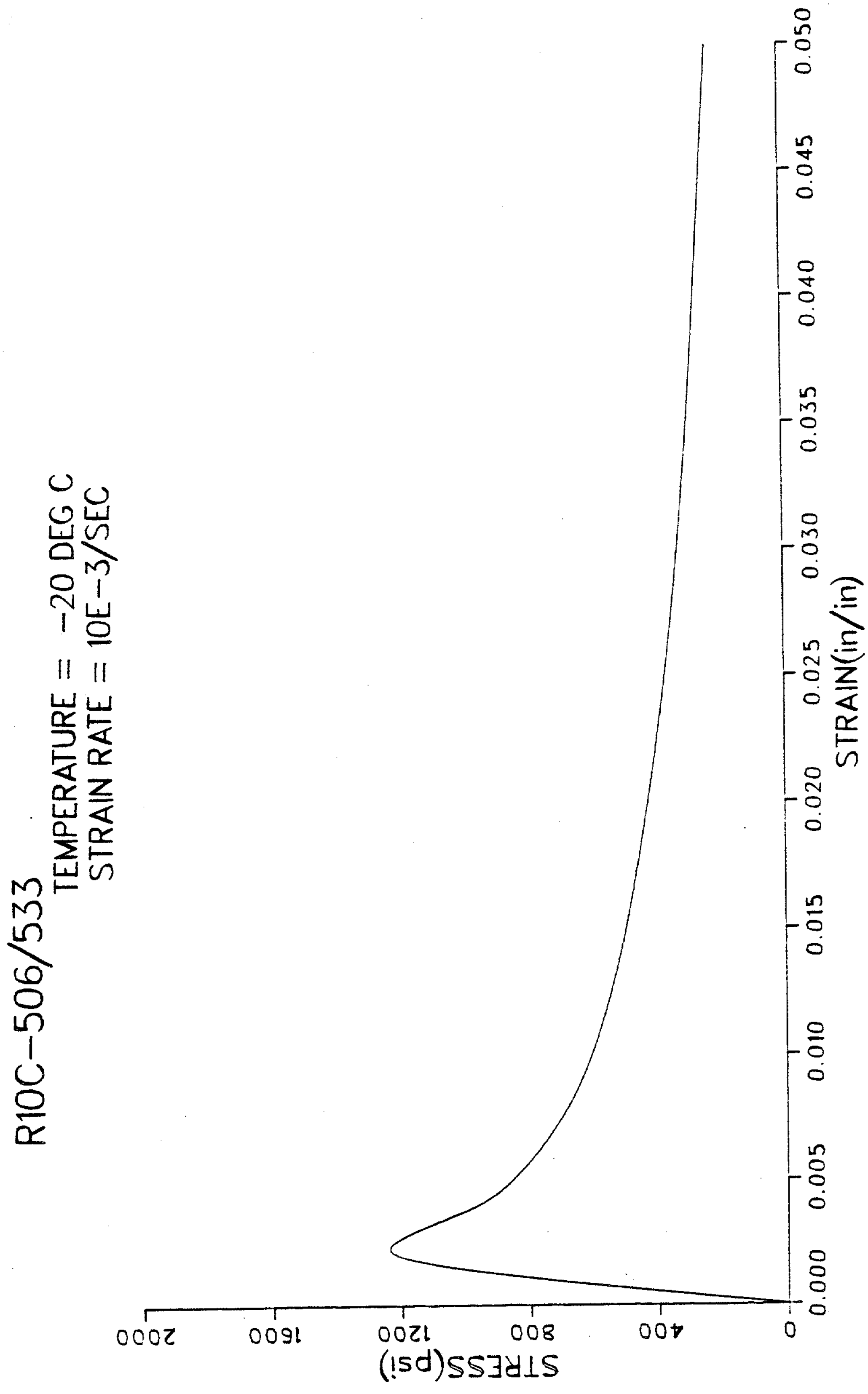

R9B-417/444
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050

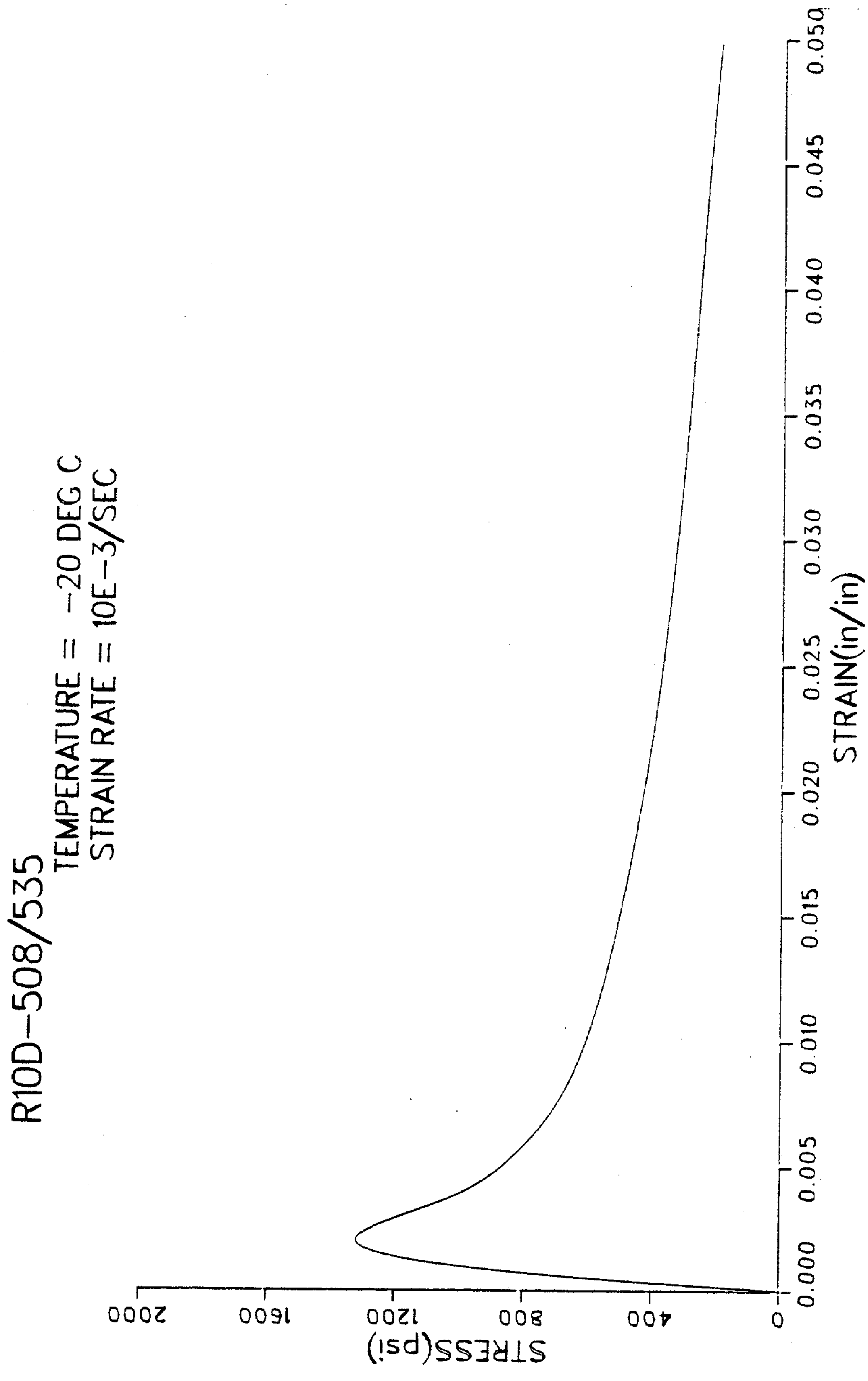

R9C-507/534
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050


R9D-348/375
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRAIN(in/in)
0.000
0.005
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
STRESS(psi)
0
400
800
1200
1600
2000


R10A–407/434
TEMPERATURE = –20 DEG C
STRAIN RATE = 10E–3/SEC
STRAIN(in/in)
STRESS(psi)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0
400
800
1200
1600
2000


R10B-449/476
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050


R10C-506/533
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050


R10D-508/535
TEMPERATURE = -20 DEG C
STRAIN RATE = 10E-3/SEC
STRESS(psi)
0
400
800
1200
1600
2000
STRAIN(in/in)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050